THE

South African Journal of Science

Volume XLIII

BEING THE

REPORT

OF THE

FORTY-FOURTH ANNUAL MEETING

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

PRETORIA
1946
1st to 5th July

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VERSLAG

VAN DIE

VIER-EN-VEERTIGSTE JAARVERGADERING

VAN DIE

SUID-AFRIKAANSE GENOOTSKAP VIR DIE BEVORDERING VAN WETENSKAP

PRETORIA
1946
1 tot 5 Julie

JOHANNESBURG:
UITGEGEE DEUR DIE GENOOTSKAP
en
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1947

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(1946, PRETORIA)

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EDITORIAL NOTE.

In connection with the changes in the Constitution adopted by the Annual General Meeting of the Association on July 4th, 1947, this Journal will in future be reduced in bulk and it is hoped that it will be improved in quality. A limit will be set to the length of papers published, and only papers of special scientific value, or scientific papers of merit for which no other suitable medium of publication exists in South Africa may be published in the Journal to the full limit. Such papers will be submitted to competent referees for comment and recommendation, whilst all suitable contributions which cannot be printed fully; will be published in the form of brief abstracts (100 to 200 words) either in this Journal or in *South African Science,* a new monthly publication of the Association which will take the place of the former quarterly Bulletin.

S. B. ASHER.

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AMPSDRAERS EN RAAD VIR 1946-47

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PROCEEDINGS OF THE FORTY-FOURTH ANNUAL GENERAL MEETING OF MEMBERS HELD AT THE TECHNICAL COLLEGE, PRETORIA, ON FRIDAY, 5th JULY, 1946, AT 10 A.M.

VERRIGTINGS VAN DIE VIER-EN-VEERTIGSTE ALGEMENE JAARVERGADERING VAN LEDE IN DIE TEGNIESE KOLLEGE, PRETORIA, OM TIEN UUR OP VRYDAG, 5 JULIE, 1946, GEHOU.

Present/Teenwoordig.—Dr. F. E. T. Krause (President/Voorsitter), Miss E. M. Ackerman, Miss R. J. Allsopp, Miss E. E. A. Archibald, Mr. S. B. Asher, Dr. R. Bigalke, Dr. A. E. H. Bleksley, Mr. F. G. Braithwaite, Miss A. E. Brueckner, Dr. F. G. Cawston, Mr. E. C. Chubb, Mr. D. G. Collett, Mr. J. Collie, Professor R. H. Compton, Mr. H. B. S. Cooke, Mr. J. E. Cosnett, Dr. G. de Kock, Professor C. G. S. de Villiers, Dr. Miriam P. de Vos, Dr. H. H. Dodds, Professor M. R. Drennan, Dr. A. L. du Toit, Dr. C. A. du Toit, Dr. R. A. Dyer, Mr. E. M. P. Evans, Dr. D. W. Ewer, Mr. F. V. Fairbrass, Mr. C. Ferguson, Dr. Beryl S. Fisher, Dr. V. F. Fitzsimons, Dr. P. J. J. Fourie, Professor A. M. M. Gericke, Mr. James Gray, Dr. C. S. Grobbelaar, Dr. J. W. Groenewald, Dr. T. D. Hall, Dr. G. N. G. Hamilton, Dr. Marguerita Henrici, Dr. A. G. Hooper, Professor A. J. T. Janse, Dr. R. J. A. Jordan, Miss P. J. Klesser, Dr. H. Knox-Shaw, Mr. D. F. Kokot, Mr. J. D. Louw, Dr. J. G. Louw, Professor W. J. Lütjeharms, Miss M. E. Malan, Mr. W. D. Malherbe, Dr. R. H. Marloth, Dr. A. McMartin, Dr. D. B. D. Meredith, Dr. Margaretha G. Mes, Mr. A. O. D. Mogg, Miss J. M. Murray, Professor John Orr, Mr. K. J. Pienaar, Professor F. E. Plummer, Mr. J. H. Power, Dr. J. I. Quin, Professor A. Quintanilha, Mr. S. J. Richards, Professor E. M. Robinson, Mr. D. F. P. Roux, Dr. Bernard Smit, Mr. J. D. Smit, Professor G. H. Stanley, Mr. J. S. Starke, Mr. P. J. Swart, Dr. Gertrud Theiler, Mr. C. J. van der Westhuizen, Dr. E. C. N. van Hoepen, Miss L. R. van Niekerk, Professor C. van Riet Lowe, Mr. G. van Son, Dr. C. M. van Wyk, Miss E. Wasserfall, Mrs. E. M. Wells, Dr. L. H. Wells, Mr. A. B. M. Whitnall, Miss J. S. Whitmore, Dr. M. Wilman, Professor H. H. Paine (Honorary General Secretary) and Mr. I. M. Sinclair (for Assistant General Secretaries).

1. **Minutes.**—The Minutes of the Forty-Third Annual General Meeting, held at Johannesburg on the 4th July, 1945, and printed on pages iii to vii of the Report of the Johannesburg Session (Volume XLII of the Journal), were confirmed.

Notule.—Die Notule van die Drie-en-veertigste Algemene Jaarvergadering gehou in Johannesburg op 4 Julie 1945, en gedruk op bladsye iii tot vii van die verslag van die Johannesburgse Byeenkoms (Deel XLII van die Journal) is goedgekeur.

2. **Greetings and Apologies.**—Greetings from the Sociedade de Estudos da Colonia de Moçambique, were brought by Professor A. Quintanilha.

The Honorary General Secretary reported that messages for a successful meeting, together with their apologies for absence, had been received from Dr. M. Boehmke, Lt.-Colonel C. Graham Botha, Mr. B. D. Malan and Mr. and Mrs. H. A. G. Jeffreys.

Groete en Verontskuldigings.—Groete van die Sociedade de Estudos da Colonia de Moçambique ontvang is van Professor A. Quintanilha.

Die Ere-algemene Sekretaris het gerapporteer dat wense vir 'n suksesvolle vergadering, saam met verontskuldigings vir afwesigheid

ontvang is van Dr. M. Boehmke, Luitenant-Kolonel C. Graham Botha, Mnr. B. D. Malan en van Mnr. en Mev. H. A. G. Jeffreys.

It was noted that apologies for absence had also been received from:

Ontvange verontskuldigings vir afwesigheid is genoteer van:

Mr./Mnr. L. L. de Kock, Professor P. R. Kirby, Mr./Mnr. D. R. McFarlane, Dr. E. Percy Phillips, Mr./Mnr. Reay H. N. Smithers and/en Mrs./Mev. H. E. Wood.

3. **Annual Report of Council for the year ended 30th June, 1946.**—The Annual Report of the Council for the year ended 30th June, 1946, having been duly suspended on the Notice Board, was taken as read and adopted.

Jaarverslag van die Raad vir die jaar tot op 30 Junie 1946.—Die Jaarverslag van die Raad vir die jaar tot op 30 Junie, 1946, wat behoorlik op die kennisgevingsbord gepubliseer was, is as gelees beskou en goedgekeur.

With reference to Item 3 of the Report, Professor John F. V. Phillips acknowledged his indebtedness to Mr. S. B. Asher for editing the Journal, as he had been unable to assist Mr. Asher during the last six years, owing to heavy commitments occasioned through the war.

Na aanleiding van Item 3 van die Verslag het Professor John F. V. Phillips sy verskuldiging aan Mnr. S. B. Asher uitgespreek vir sy redaksie van die Joernaal, aangesien hy, as gevolg van swaar verpligtinge deur die oorlog teweeggebring, gedurende die afgelope ses jaar nie in staat was om Mnr. Asher by te staan nie.

4. **Reorganisation of the Association.**—Arising out of the Annual Report, Professor John F. V. Phillips informed members that the Council had appointed a Committee, termed the Future Policy and Activities Committee, to consider the reorganisation of the Association, and he gave a brief outline of some of the matters which had been referred to this Committee.

Dr. R. H. Marloth raised the question of the Council making representations to the Public Service Commission to procure special leave to attend the Annual Meetings of this Association for members employed by the Government, as such attendance was of educational value, and it was hardly fair that members should have the time spent at meetings deducted from their annual leave.

Dr. Bernard Smit pointed out that representations on this matter had been made to the Public Service Commission some years previously, when the Commission had replied that, if the heads of the Government Departments concerned wished their officers to attend the Annual Meetings of this Association, they were authorised to make arrangements accordingly.

Mr. A. O. D. Mogg, Mr. E. M. P. Evans, Mr. H. B. S. Cooke, Mr. James Gray, Dr. T. D. Hall, Dr. J. I. Quin and Professor C. van Riet Lowe made certain suggestions in regard to adherence to the programme of the meeting, expediting publication of the Journal and the issue of a Scientific Bulletin.

On the proposal of Mr. E. C. Chubb, it was unanimously agreed that the Council consider the various suggestions made and that, if deemed advisable, it be authorised to carry out these suggestions as far as the finances of the Association allow.

Re-organisasie van die Vereniging. — Na aanleiding van die Jaarverslag, het Professor John F. V. Phillips lede in kennis gestel dat die Raad 'n Komitee aangestel het, genoem die Toekomstige Beleid en Werksaamhede Komitee, om die re-organisasie van die Vereniging te oorweeg, en hy het 'n kort skets van sommige van die sake wat na hierdie Raad verwys is gegee.

Dr. R. H. Marloth het die vraag ter sprake gebring dat die Raad vertoë rig tot die Staatsdiens Kommissie om spesiale verlof vir lede in die Staatsdiens te verkry om die Jaarlikse Vergaderings van hierdie Vereniging by te woon, aangesien sulke bywoning van opvoedkundige waarde is, en dit nie eintlik regverdig is dat die tyd wat lede in vergaderings deurbring van hulle jaarlikse verlof afgetrek moet word nie.

Dr. Bernard Smit het daarop gewys dat vertoë in hierdie verband 'n aantal jare vroeër tot die Staatsdiens Kommissie gerig is, en die Kommissie het geantwoord dat as die hoofde van die betrokke Staatsdepartemente verlang het dat hulle amptenare die Jaarlikse Vergaderings van hierdie Vereniging bywoon, hulle gemagtig was om daarvolgens reëlings te tref.

Mnr. A. O. D. Mogg, Mnr. E. M. P. Evans, Mnr. H. B. S. Cooke, Mnr. James Gray, Dr. T. D. Hall, Dr. J. I. Quin en Professor C. van Riet Lowe het sekere voorstelle gemaak in verband met die navolging van die program van die vergadering, verspoediging van publikasie van die Joernaal, en die uitgee van 'n Wetenskaplike Bulletin.

Op voorstel van Mnr. E. C. Chubb, is dit eenstemmig besluit dat die Raad die verskillende voorstelle wat gemaak is sou oorweeg, en dat, as dit raadsaam blyk, hulle gemagtig word om hierdie voorstelle, sover die finansies van die Vereniging dit toelaat, uit te voer.

5. **Annual Report of the Honorary General Treasurer and Statement of Accounts for the year ended 31st May, 1946.**—The Honorary General Treasurer's Report and the Statement of Accounts for the year ended 31st May, 1946, having been duly displayed on the Notice Board, were taken as read and adopted.

Die Jaarverslag van die Ere-algemene Penningmeester en Staat van Rekeninge vir die jaar tot op 31 Mei 1946, wat behoorlik op die Kennisgewingsbord gepubliseer is, is as gelees beskou en goedgekeur.

6. **Annual Report of the Honorary Librarian for the year ended 31st May, 1946.**—The Annual Report of the Honorary Librarian for the year ended 31st May, 1946, having been duly displayed on the Notice Board, was taken as read and adopted.

Die Verslag van die Ere-Bibliotekaris vir die jaar tot op 31 Mei 1946, wat behoorlik op die Kennisgewingsbord gepubliseer is, is as gelees beskou en goedgekeur.

7. **Election of General Officers and Council Members for 1946-1947.**—The following members were elected:—

Verkiesing van lede tot Algemene Ampsdraers en Raadslede vir 1946-1947.—Die volgende lede is gekies.—

OFFICERS/AMPSDRAERS.

President: Prof. H. H. Paine. **Vice-Presidents/Vise-Voorsitters:** Dr. G. de Kock, Dr. S. H. Skaife, Dr. E. G. Malherbe, Dr. J. S. Paraskevopoulos. **Honorary General Secretaries/Ere-Algemene Sekretarisse:** Dr. A. E. H. Bleksley, Mr./Mnr. Reay H. N. Smithers. **Honorary**

General Treasurer/Ere-Algemene Penningmeester: Mr./Mnr. Jas. Gray. **Honorary Editor/Ere-Redakteur:** Prof. John F. V. Phillips. **Honorary Associate Editor/Ere-Mederedakteur:** Mr./Mnr. S. B. Asher. **Honorary Librarian/Ere-Bibliotekaris:** Mr./Mnr. P. Freer.

Professor H. H. Paine expressed his appreciation of the honour conferred on him by his election as President for the 1946-1947 Session, and undertook to do all in his power to further the interests of the Association.

Professor H. H. Paine het sy waardering uitgespreek vir die eer wat hom bewys is deur sy verkiesing tot President vir die jaar 1946-1947, en het onderneem om alles in sy vermoë te doen om die belange van die Genootskap te bevorder.

COUNCIL MEMBERS/RAADSLEDE.

Transvaal—Witwatersrand: Mr./Mnr. J. T. Allan, Miss/Mej. T. Alper, Mr./Mnr. S. B. Asher, Mr./Mnr. H. B. S. Cooke, Mr./Mnr. R. Craib, Dr. F. W. Fox, Dr. A. Galloway, Dr. T. D. Hall, Prof. P. R. Kirby, Prof. I. D. MacCrone, Prof. L. F. Maingard, Mr./Mnr. B. D. Malan, Dr. G. Martinaglia, Dr. A. G. Oettlé, Prof. John Orr, Dr. J. B. Robertson, Dr. B. Segal, Prof. G. H. Stanley, Prof. C. van Riet Lowe, Dr. L. H. Wells and/en Mr./Mnr. H. Wilson. **Pretoria:** Dr. R. A. Dyer, Dr. P. J. du Toit, Dr. V. F. Fitzsimmons, Mr./Mnr. D. F. Kokot, Dr. M. G. Mes, Dr. L. T. Nel, Dr. J. I. Quin, Dr. B. Smit and/en Dr. C. R. van der Merwe. **Outside District/Buite distrik:** Prof. A. P. G. Goossens.

Cape of Good Hope—Cape Peninsula and District/Kaapse skiereiland en distrik: Lt.-Col./Luitenant-Kol. C. Graham Botha, Mr./Mnr. L. de Kock, Dr. A. L. du Toit, Mr./Mnr. G. W. Lyon, Mr./Mnr. D. R. Macfarlane and/en Col./Kol. J. G. Rose. **Stellenbosch and District/en distrik:** Mr./Mnr. F. J. S. Anders and/en Prof. B. de St. J. van der Riet. **East London/Oos-Londen and/en Port Elizabeth:** Mr./Mnr. H. C. Gardham. **Grahamstown/Grahamstad, Kingwilliamstown and District/en distrik:** Prof. J. Omer-Cooper. **Kimberley:** Mr. Mnr. J. H. Power. **Oudtshoorn:** Dr. M. Boehmke. **Outside Districts/Buite distrik:** Dr. C. W. Mally.

Natal—Durban and District/en distrik: Mr./Mnr. F. G. Braithwaite, Mr./Mnr. E. C. Chubb, and/en Dr. H. H. Dodds. **Pietermaritzburg and outside districts/en buite distrik:** Prof. S. F. Bush, Mr./Mnr. F. R. Paver.

Orange Free State—Bloemfontein: Dr. M. Henrici and/en Dr. E. C. N. van Hoepen.

Southern Rhodesia—Salisbury: Lt.-Col./Luitenant-Kol. N. P. Sellick.

8. **Addition of Clause 43 to the Constitution.**—Professor C. van Riet Lowe moved the addition to the Constitution of the following clause, which had been considered by the Council in accordance with the provisions of Clause 39 of the Constitution:—

"43. **Certificate of Merit:**

(a) Council may award Certificates of Merit to such persons as have contributed materially to the advancement of knowledge in a branch of science in which they are not professionally or normally engaged.

(b) The award shall apply primarily to persons not in possession of any scientific degree or qualifications, but who have, in the

opinion of the Council, done so much for science as to justify the award.

(c) The award may be made to persons who are not members of the Association.

(d) The total number of Certificates awarded during any one year shall not exceed three and not more than one Certificate shall be awarded in any year for any one Section. The number of holders of Certificates shall at no time exceed eighteen.

(e) **Procedure:**

(1) Any member of the Association may nominate a candidate for the award of a Certificate.

(2) Such a nomination shall be lodged with the Assistant General Secretaries at least one month before the commencement of the Annual Session and shall contain a full statement of the candidate's services to science.

(3) Each nomination shall forthwith be transmitted to the President of the Section concerned, who shall submit such nomination as soon as possible to his Sectional Committee.

(4) The Sectional Committee shall proceed to make a recommendation to Council provided that a recommendation in favour of a candidate must have obtained a three-fourths majority of all members present. In the event of there being more than one nomination, the Sectional Committee must submit the names in order of preference.

(5) The recommendation of the Sectional Committee shall then be transmitted through the Assistant General Secretaries to the Council of the Association and, if it is favourable, the nomination shall be submitted to the full Council for approval by ballot.

(6) The Certificate of Merit, in a form approved by the Council, shall be transmitted to the recipient by the President of the Association."

Mr. H. B. S. Cooke seconded the motion of Professor van Riet Lowe, after which the addition to the Constitution of Clause 43, as shown above, was carried unanimously by the meeting.

Byvoeging van Klousule 43 by die Grondwet.—Professor C. van Riet Lowe het die byvoeging by die Grondwet van die volgende klousule, wat ooreenkomstig die bepalings van Klousule 39 van die Grondwet deur die Raad oorweeg is, voorgestel:—

„43. **Sertifikaat van Verdienste:**

(a) Die Raad mag Sertifikate van Verdienste toeken aan sulke persone wat aanmerklik bygedra het tot die bevordering van kennis in 'n vertakking van die wetenskap waarmee hulle nie professioneel of gewoonlik besig is nie.

(b) Die toekenning sal hoofsaaklik betrekking hê op persone wat nie enige wetenskaplike graad óf kwalifikasie besit nie, maar wat, na die mening van die Raad, soveel vir die wetenskap gedoen het as om die toekenning te regverdig.

(c) Die toekenning mag aan persone gemaak word wat nie lede van die Vereniging is nie.

(d) Die totaal aantal Sertifikate in enige jaar toegeken sal nie meer as drie wees nie, en nie meer as een Sertifikaat sal in enige jaar vir enige Afdeling toegeken word nie. Die aantal Sertifikaathouers sal nooit meer as agtien wees nie.

(e) **Prosedure:**

(1) Enige lid van die Vereniging mag 'n kandidaat vir die toekenning van 'n Sertifikaat benoem.

(2) So 'n benoeming sal by die Assistent-Algemene Sekretarisse minstens een maand voor die aanvang van die Algemene Sitting ingedien word, en sal 'n volledige verklaring van die kandidaat se dienste aan die wetenskap bevat.

(3) Elke benoeming sal onmiddellik aan die Voorsitter van die betrokke Afdeling oorgelewer word, wat sulke benoeming so spoedig moontlik by sy Afdelingskomitee sal indien.

(4) Die Afdelingskomitee sal vervolgens 'n aanbeveling aan die Raad doen, op voorwaarde dat 'n aanbeveling ten gunste van 'n kandidaat 'n drie-kwart meerderheid van al die teenwoordige lede behaal het. In geval daar meer as een benoeming is, moet die Afdelingskomitee die name volgens voorkeursrang indien.

(5) Die aanbeveling van die Afdelingskomitee sal dan deur die Assistent-Algemene Sekretarisse aan die Raad van die Vereniging oorgelewer word, en, as dit gunstig is, sal die benoeming by die volle Raad ingedien word vir goedkeuring deur stembrief.

(6) Die Verdienstesertifikaat sal, in 'n vorm deur die Raad goedgekeur, deur die Voorsitter van die Vereniging aan die ontvanger oorgelewer word.

Mnr. H. B. S. Cooke het die mosie van Professor van Riet Lowe sekonder, waarna die byvoeging van Klousule 43 by die Grondwet, soos hierbo aangedui, eenstemmig deur die vergadering aangeneem is.

9. **Annual Meeting, 1947.**—An invitation from the Town Council of Oudtshoorn for the Association to hold its Annual Session in that town in 1947 was accepted unanimously and enthusiastically.

Professor A. Quintanilha, in bringing greetings from the Sociedade de Estudos, brought also an invitation from Lourenco Marques to hold the Annual Meeting there in 1948.

It was agreed that this invitation be referred to the Council for its favourable consideration and that, in the meantime, a letter of thanks be sent to Lourenco Marques.

Jaarlikse Vergadering, 1947.—'n Uitnodiging van die Dorpsraad van Oudtshoorn vir die Vereniging om sy Jaarlikse Sitting in 1947 in daardie dorp te hou is eenparig en geesdriftig aangeneem.

Professor A. Quintanilha, toe hy groete bring van die Sociedade de Estudos da Colonia de Moçambique, het ook 'n uitnodiging van daardie Genootskap gebring om die Jaarlikse Vergadering van 1948 in Lourenco Marques te hou.

Dit is besluit dat hierdie uitnodiging na die Raad vir gunstige oorweging verwys word en dat, intussen, 'n brief van danksegging aan die Voorsitter van die Sociedade de Estudos da Colonia de Moçambique gestuur word.

10. **Teaching of Biology in South African Schools.**—On the proposal of Dr. J. I. Quin, seconded by Professor A. J. T. Janse, the following resolution, which had been referred to the Annual General

Meeting by Sections C, D and F, was adopted and referred to the Council for action:—

"This Association realizes the great and growing importance of the teaching of biology in schools throughout South Africa. In order to ensure that the teaching of biological subjects is placed on a sound basis, Council is urged to establish liaison with other interested scientific bodies and to consider ways and means of presenting concrete proposals before the education authorities concerned."

Onderwys in Biologie in Suid-Afrikaanse Skole.—Op voorstel van Dr. J. I. Quin, deur Professor A. J. T. Janse sekondeer, is die volgende besluit, wat deur Afdelings C, D en F na die Jaarlikse Algemene Vergadering verwys is, aangeneem en na die Raad vir optrede verwys:—

„Hierdie Vereniging besef die groot en toenemende belangrikheid van die onderwys in biologie in skole dwarsdeur Suid-Afrika. Ten einde te verseker dat die onderwys in biologiese vakke op 'n vaste fondament gebou word, word die Raad aangespoor om 'n skakel met ander belangstellende wetenskaplike liggame tot stand te bring en om middele te oorweeg om tasbare voorstelle aan die betrokke onderwysoutoriteite voor te lê."

11. **By-products from Wool Washeries.**—Mr. F. G. Braithwaite stated that the following considerations arose from a review of the by-products from wool washeries:—

In contrast to other countries, South Africa confines itself almost entirely to the scouring of lox and other inferior types of wool. The high proportions of suint and vegetable matter in these types provide problems in scouring and recovery of by-products not encountered in the handling of fleece lines, so that research conducted overseas and the methods in satisfactory use there are seldom applicable to South African conditions.

The main problems requiring investigation are:—

(1) Scouring systems.

(2) The commercial recovery of wool grease and potash salts.

(3) The properties of wool grease and its industrial application.

With regard to (1)—scouring systems, it is considered essential that investigations should proceed in close collaboration with an institution capable of exercising the desired control over the properties of the scoured wool.

The value of the by-products now going to waste in the Union's wool washeries already amounts to well over a quarter of a million sterling annually. After a discussion of the problem, Section B feels that this problem may fall within the scope of the activities of the South African Council for Scientific and Industrial Research, and commends it to the attention of that body, as being of sufficient importance to warrant intensive investigation.

It was agreed that this matter be referred to the Council for action.

Byprodukte van Wolwasserye.—Mnr. F. G. Braithwaite het verklaar dat die volgende oorweginge uit 'n oorsig van die byprodukte van wolwasserye voortgespruit het:—

In teenstelling met ander lande, beperk Suid-Afrika sigself byna geheel-en-al tot die skoonmaak van bokwol en ander minder-

waardige tipes wol. Die hoë mate skaapwolvet en plantaardige stof in hierdie tipes bring probleme in die skoonmaak en herwinning van byprodukte wat nie in die behandeling van vliessoorte teëgekom word nie, sodat navorsing wat oorsee gedoen word en die metodes wat daar met bevrediging gebruik word selde van toepassing op Suid-Afrikaanse omstandighede is.

Die hoofprobleme wat ondersoek vereis is:—

(1) Skoonmaakstelsels.

(2) Die kommersiële herwinning van wolvet en potassiumsoute.

(3) Die eienskappe van wolvet en hulle industriële toepassing.

Met betrekking tot (1) — skoonmaakstelsels, word dit as noodsaaklik beskou dat navorsinge in noue samewerking sal voortgaan met 'n inrigting wat in staat is om die gewenste beheer oor die eienskappe van die skoongemaakte wol uit te oefen.

Die waarde van die byprodukte wat nou in die Unie se wolwasserye verlore gaan beloop reeds jaarliks ver oor 'n kwartmiljoen sterling. Na 'n bespreking van die probleem, voel Afdeling B dat hierdie probleem binne die perke van die bedrywighede van die Suid Afrikaanse Raad vir Wetenskaplike en Industriële Navorsing mag val, en dra dit op aan die aandag van daardie liggaam, as van genoeg belangrikheid om intensiewe navorsing te regverdig.

Dit is besluit dat die saak na die Raad vir handeling verwys word.

12. **Resolutions from Section D:**

(a) **The Milk Industry in South Africa.**—On the proposal of Professor E. M. Robinson, the following resolution was adopted and referred to the Council for action:—

"This Association realizes the urgent necessity for placing the Milk Industry in South Africa on a new basis. This will involve

(1) improved conditions of animal health and husbandry;

(2) improved standards of dairy hygiene;

(3) improved marketing methods;

(4) rendering milk safer for human consumption; and

(5) rationalization of distribution.

In view of these considerations, Council is urged to take these matters up with the authorities concerned."

(b) **Protection and Control of the Fauna, Flora and Sanctuaries in South Africa.**—On the proposal of Dr. R. Bigalke, the following resolution was adopted and referred to the Council for action:—

"If the present negotiations with the Minister of Lands to convene a meeting of all bodies interested in the protection and preservation of the Fauna and Flora of South Africa should fail, this meeting requests Council to take the necessary steps to convene such a meeting in Pretoria in September or October this year, and to invite one representative from each of the following to attend:—

The Departments of Lands, Agriculture and Public Health; the four Provincial Councils; The Kruger National Park Board;

The Natal Reserves Board; the four Universities; The Royal Society of South Africa; Die Suid-Afrikaanse Akademie vir Wetenskap en Kuns; The Historical Monuments Commission; the South African Museums; The Veld Trust; The South African Agricultural Union; The Wild Life Protection Society; The Botanical Association; The Ornithological Society; The South African Biological Society; The National Zoological Gardens Board of Trustees; and such other bodies as are interested."

(c) **Disappearance of Wild Life Along River Courses in South Africa.**—On the proposal of Dr. F. G. Cawston, the following resolution was adopted, and it was agreed that it be referred to the Sub-Committee which had been appointed by the Council to consider the protection and control of the fauna, flora and sanctuaries of South Africa:—

"Disappearance of wild life along river courses in South Africa is a serious menace to those natural assets on which both human beings and stock depend. It is partly due to drought and civilised interference with the vegetation of river-banks.

A mere presence, in a few specimens of a wild animal, of organisms which cannot well be differentiated from those responsible for human and stock disease is not sufficient justification for wholesale attack on the species.

Species not themselves carriers of disease but closely-allied to the intermediate hosts should be carefully protected and more consideration is due to the fact that some species which serve as carriers of infection do so at specific seasons of the year alone."

Besluite van Afdeling D:

(a) **Die Melkindustrie in Suid Afrika.**—Op voorstel van Professor E. M. Robinson is die volgende besluit aangeneem en na die Raad vir handeling verwys:—

„Hierdie Vereniging besef die dringende noodsaaklikheid om die Melkindustrie in Suid-Afrika op 'n nuwe grondslag te plaas.

Dit sal meebring

(1) verbeterde toestande van dierewelstand en veeteelt;

(2) verbeterde maatstawwe vir melkeryhigiëne;

(3) verbeterde markmetodes;

(4) veiligmaking van melk vir menslike verbruik; en

(5) rasionalisasie van verspreiding.

Met 'n oog op hierdie oorwegings, word die Raad aangespoor om die saak met die betrokke outoriteite te behandel."

(b) **Beskerming en Beheer van die Fauna, Flora en Vryplaas in Suid-Afrika.**—Op voorstel van Dr. R. Bigalke is die volgende besluit aangeneem en na die Raad vir handeling verwys:—

„As die huidige onderhandelinge met die Minister van Lande om 'n vergadering van alle liggame wat belangstel in die beskerming en behouding van die Fauna en Flora van Suid-Afrika misluk, versoek hierdie vergadering die Raad om die nodige stappe te doen om so 'n vergadering in Pretoria in September of Oktober van hierdie jaar byeen te roep, en om een verteenwoordiger van elk van die volgende uit te nooi om dit by te woon:—

Die Departemente van Lande, Landbou en Volksgesondheid; die vier Provinsiale Rade; The Kruger National Park Board;

The Natal Reserves Board; die vier Universiteite; The Royal Society of South Africa; Die Suid-Afrikaanse Akademie vir Wetenskap en Kuns; The Historical Monuments Commission; die Suid-Afrikaanse Museums; The Veld Trust; The South African Agricultural Union; The Wild Life Protection Society; The Botanical Association; The Ornithological Society; The South African Biological Society; The National Zoological Gardens Board of Trustees; en sulke ander liggame wat belangstel.

(c) **Verdwyning van Wildelewe langs Rivierlope in Suid-Afrika.**— Op voorstel van Dr. F. G. Cawston, is die volgende besluit aangeneem, en dit is besluit dat dit na die Onderkomitee verwys word wat deur die Raad aangestel is om die beskerming en beheer van die fauna, flora en vryplase van Suid-Afrika te oorweeg:—

„Verdwyning van wildelewe langs rivierlope in Suid-Afrika is 'n ernstige gevaar vir daardie natuurlike besit waarop beide mense en vee steun. Dit is gedeeltelik te wyte aan droogte en beskaafde bemoeiing met die plantegroei van rivierwalle.

Bloot die aanwesigheid, in 'n paar voorbeelde van 'n wildedier, van organismes wat nie maklik kan onderskei word van dié wat mense- en dieresiekte veroorsaak nie is nie voldoende regverdiging vir algemene aanval op die soort nie.

Soorte nie in sigself draers van siekte nie, maar nou verbind aan die tussengashere, behoort noukeurig beskerm te word en meer aandag behoort gewy te word aan die feit dat soorte wat as draers van besmetting dien dit alleen gedurende sekere jaargetye doen."

13. **Surface and Underground Water Supplies in South Africa.**— On the proposal of Dr. A. L. du Toit, the meeting adopted and referred to the Council for action the following resolution, which had been referred to the Annual General Meeting by a Committee appointed at the meeting at which the Symposium on "The Water Resources of South Africa" had been presented:—

"That, in view of certain disturbing tendencies, which are becoming more marked, the Government is urged

(a) to investigate thoroughly the vital questions of the composition, quality, contamination and sterilization of surface and underground water supplies in the Union; and

(b) to increase the scientific staffs of the departments of State concerned therewith, so as to enable such varied researches to be actively prosecuted."

Oppervlakkige en Ondergrondse Watervoorrade in Suid-Afrika.— Op voorstel van Dr. A. L. du Toit, het die vergadering die volgende besluit wat na die Jaarlikse Algemene Vergadering verwys is deur 'n Komitee wat aangestel is op die vergadering waarop die symposium oor „The Water Resources of South Africa" aangebied is aangeneem en na die Raad vir handeling verwys:—

„Dat, met die oog op sekere verontrustende neiginge, wat steeds meer merkbaar word, die Regering aangespoor word

(a) om die belangrike vraagstukke van die komposisie, kwaliteit, besmetting en suiwering van oppervlakkige en ondergrondse watervoorrade in die Unie deeglik te ondersoek; en

(b) om die wetenskaplike stawwe van die Regeringsdepartemente daarby betrokke te vermeerder, om dit moontlik te maak dat sulke veelsydige navorsings daadwerklik voortgesit kan word."

14. **Votes of Thanks.**—On the proposal of Professor H. H. Paine, a unanimous vote of thanks was accorded to the following:—

To His Worship the Mayor (Councillor C. W. Sinclair), the Deputy-Mayor (Councillor L. C. J. Besaans), the City Council, the Mayoress and the Deputy-Mayoress of the City of Pretoria, and the members of the Organising Committee, for the excellent arrangements for the Meeting.

To the Principal of the Pretoria Technical College (Professor J. P. Duminy) and his Council for the use of the College buildings.

To the ladies who had arranged for morning and afternoon teas.

To Mrs. F. E. T. Krause for the luncheon she had given at the Pretoria Country Club to the ladies attending the Meeting.

To the ladies and gentlemen who kindly provided transport for the excursions.

For hospitality on excursions: To the Director and Staff of Iscor, the Pretoria Reserves Advisory Committee, the Director and Staff of the Onderstepoort Veterinary Research Laboratory, the Director of the National Zoological Gardens, the Director of the South African Mint, the President of the South African Council for Scientific and Industrial Research, the Director of the Radcliffe Observatory.

To the South African Broadcasting Corporation for facilities for broadcasting daily summaries of the Sessional programme.

To the following for the exhibits which had proved of great interest: The Director and Staff of Iscor, the President and Staff of the South African Council for Scientific and Industrial Research, the Pretoria Technical College, the Geological Survey, the Division of Botany and Plant Pathology, the Department of Botany of the University of Pretoria, the Division of Chemical Services, the Irrigation Department.

For privileges of honorary membership during the Session: To the Pretoria Club, the Pretoria Women's Club, the Pretoria Country Club, the Zwartkop Country Club, the Pretoria Golf Club, Murray's Golf Club.

To the Press for reporting papers read at the Meetings.

To the Honorary Auditors (Messrs. Alex. Aiken and Carter) for their services in carrying out the audit for the year 1945-1946.

Mr. E. C. Chubb proposed a hearty vote of thanks to the President (Dr. F. E. T. Krause) for the valuable services he had rendered the Association during his term of office, this vote of thanks being accorded with acclamation.

The President, in acknowledging Mr. Chubb's remarks, expressed his appreciation of the support he had received from the Council.

This concluded the business and the meeting terminated at 11.50 a.m.

Mosies van Dank.—Op voorstel van Professor H. H. Paine is eenparig die dank van die vergadering gebring aan dié volgende:—

Aan Sy Edele die Burgemeester (Raadslid C. W. Sinclair), die Onderburgemeester (Raadslid L. C. J. Besaans), die Burgemeesteres Mev. Sinclair en die Onderburgemeesteres Mev. Besaans en die lede van die organiserende Komitee, vir hulle uitstekende skikkinge vir die byeenkoms.

Aan die Prinsipaal van die Tegniese Kollege (Professor J. P. Duminy) en sy Raad vir die gebruik van die Kollege-geboue.

Aan die dames wat môre-en-agtermiddag-tee verskaf het.

Aan Mev. F. E. T. Krause vir die verskaffing van middageet vir die dames op die Pretoria Country Club.

Aan die dames en here wat vriendelik vervoer vir die ekskursies verskaf het.

Vir gasvryheid op ekskursies aan: Die Direkteur en Staf van Iskor, die Pretoriase Reserwes Adviserende Komitee, die Direkteur en Staf van die Onderstepoort Veeartsenykundige Navorsingslaboratorium, die Direkteur van die Nasionale Dieretuin, die Direkteur van die Suid-Afrikaanse Munt, die Voorsitter van die Suid-Afrikaanse Raad vir Wetenskaplike en Industriële Navorsing, die Direkteur van die Radcliffe Sterrewag.

Aan die Suid-Afrikaanse Uitsaaikorporasie vir geleenthede om daaglikse opsommings van die Sittingsprogram uit te saai.

Aan die volgende vir uitstallings wat baie interessant was: Die Direkteur en Staf van Iskor, die Voorsitter en Staf van die Suid-Afrikaanse Raad vir Wetenskaplike en Industriële Navorsing, die Pretoriase Tegniese Kollege, die Geologiese Opname, die Afdeling van Plant- en Plantsiektekunde, die Departement van Plantkunde van die Universiteit van Pretoria, die Afdeling van Chemiese Dienste, die Afdeling van Veeartsenykundige Dienste, die Besproeiingsdepartement.

Vir voorregte van erelidmaatskap gedurende die Sitting aan: Die Pretoria Club, die Pretoria Women's Club, die Pretoria Country Club, die Zwartkop Country Club, die Pretoria Golf Club, Murray's Golf Club.

Aan die Pers vir verslaggewing van verhandelinge op die Vergadering gelees.

Aan die Ereouditeurs (Mnre. Alex Aiken en Carter) vir hulle dienste in die uitvoer van die ouditering van die jaar 1945-1946.

Mnr. E. C. Chubb het 'n hartlike mosie van dank aan die Voorsitter (Dr. F. E. T. Krause) ingestel vir die waardevolle dienste wat hy gedurende sy dienstyd aan die Vereniging bewys het, en hierdie mosie van dank is met applous toegestaan.

Die Voorsitter het, in antwoord op Mnr. Chubb se woorde, sy waardering uitgespreek vir die ondersteuning wat hy van die Vereniging ontvang het.

Dit het die verrigtinge afgesluit en die vergadering het om 11.50 v.m. gesluit.

REPORT OF COUNCIL FOR THE YEAR ENDING 30th JUNE, 1946.
VERSLAG VAN DIE RAAD VIR DIE JAAR TOT OP 30 JUNIE 1946.

1. **Obituary.**—Your Council reports with regret the deaths of the following members.

In Memoriam.—U Raad gee met leedwese kennis van die oorlyde van die volgende lede.

Mr. Percy Cazalet, Dr. G. Burnham King, Dr. P. W. Laidler, Mr. H. B. Maufe, Mr. W. R. Owens, Dr. A. W. Rogers, Professor E. Warren, Dr. H. E. Wood and Colonel W. H. W. Young.

Dr. Wood, whose death is recorded above, joined the Association in 1906, was President for the year 1929-1930, and was Honorary Secretary for a period of twenty-three years. Your Council wishes to place on record its great appreciation of the services rendered by Dr. Wood in furthering the interests and advancement of the Association.

Dr. Wood, wie se oorlyde hierbo vermeld is, het in 1906, by die Genootskap aangesluit, was President vir die jaar 1929-1930 en Ere-algemene Sekretaris vir drie-en-twintig jaare. U Raad wens sy groot waardering te boekstaaf van die dienste deur Dr. Wood bewys by die bevordering van die belange en die vooruitgang van die Genootskap.

2. **Membership.**—Since the last report, one hundred and eighteen members have joined the Association, two have been reinstated, nine have died, twelve have resigned and the names of two members have been removed from the Membership List in accordance with the provisions of Clause 7 of the Constitution.

The following table shows a comparative list of the geographical distribution of membership as at the 30th June, 1945, and the 30th June, 1946.

Ledetal.—Sedert die jongste verslag het honderd-en-agtien lede by die Genootskap aangesluit, twee is herstel, nege is oorlede, twaalf het bedank en die name van twee lede is van die Ledelys geskrap ooreenkomstig Klousule 7 van die Konstitusie.

Die volgende lys toon vergelykenderwys, die geografiese voorkoms van lede op 30 June 1945 en 30 Junie 1946.

	1944	1945
Transvaal	396	472
Cape of Good Hope	156	162
Natal	70	79
Orange Free State	21	23
Southern and Northern Rhodesia	12	14
South-West Africa	1	1
Moçambique	2	3
Abroad	28	29
	686	783

3. **The Journal.**—Volume XLII of the "South African Journal of Science", being the Annual Report of the Association for the year ending 30th June, 1945, is still in the hands of the binders and will be circulated to the members early in July.

It consists of 308 pages and contains the Address of the President of the Association, six Sectional Presidential Addresses, and thirty-five other papers, of which twenty-eight were printed in full, eight in abstract and six in title only, together with Accounts, Indexes, etc.

Die „Journal".—Deel XLII van de Suid-Afrikaanse Joernal van Wetenskap, wat die jaarverslag van die Genootskap vir die jaar tot op 30 Junie 1945 bevat, is nog in hande van die binders, en vroeg in Julie aan die lede voorgelê sal word. Dit het uit 308 bladsye bestaan en het die rede van die President van die Genootskap, ses Voorsitterstoesprake aan afdelings, en 35 lesings waarvan agt-en-twintig volledig, agt in abstracto en ses slegs die tietel, benewens rekeninge, inhoudsopgawe, ens., bevat.

4. **Quarterly Bulletins.**—Three bulletins were issued during the year under review, in October, 1945, March and June, 1946.

Kwartaal-Bulletins.—Gedurende die jaar is drie bulletins uitgegee respektiewelik in Oktober 1945 en Maart en Junie 1946.

5. **South Africa Medal and Grant, 1946.**—No nomination.

Suid-Afrika-Medalje en Skenking, 1946.—Geen benoeming.

6. **British Association Medal and Grant, 1946.**—The Council of the British Association has awarded this prize for the year 1946 to Mr. C. C. Kritzinger, Zoological Institute, University of Stellenbosch, for his monograph entitled "The Cranial Anatomy and Kinesis of the South African Amphisbaenid *Monopeltis capensis* Smith".

Die Raad van die Britse Genootskap het die „British Association Medal" en skenking vir die jaar 1946 toegeken aan Mnr. C. C. Kritzinger vir sy monografie getitel „The Cranial Anatomy and Kinesis of the South African Amphisbaenid *Monopeltis capensis* Smith".

7. **Donations/Gifte.**—The thanks of the Association are due to the Honourable the Minister of Finance and of Education for a grant of £250 towards the expenses of the publication of the Journal, and to the Johannesburg Municipality for a grant of £100.

Die Genootskap spreek sy dank uit aan Sy Ed. die Minister van Finansië en Onderwys vir 'n gif van £250 tot die onkoste van die uitgawe van die Journal, en aan die Johannesburgse Munisipaliteit vir 'n toelae van £100.

8. **Resolutions adopted by Annual General Meeting, 4th July, 1945:**

(a) **Protection and Control of the Fauna, Flora and Sanctuaries in South Africa.** (See also Council's Reports, 1944, item 9 (a), and 1945, item 9). The Minister of Lands has agreed to convene a meeting of all interests concerned.

(b) **War-time Destruction of Zoological and Botanical Material in Europe.** The Council has received information from Sir David Chadwick that the destruction is much less than was feared, the collections in France, Belgium, Denmark and the United Kingdom being intact, and those in Holland mostly so. Conditions in Italy and Germany were not yet known.

Besluite aangeneem deur die Algemene Jaarvergadering, 4 Julie 1945:

(a) **Beskerming en beheer van die fauna, flora en sanctuaria in Suid-Afrika.** (Verslag van die Raad 1944, item 9 (a), en 1945, item 9.) Die Minister van Lande het ingestem om 'n vergadering te roep van almal wat daarby belang het.

(b) **Vernieling van Soölogiese en Botaniese Materiaal in Europa gedurende die Oorlogspare.** Die Raad het informasie van Sir David Chadwick ontvang dat die vernieling baie minder is as

waarvoor gevrees was, aangesien die versamelinge in Frankryk, België, Denemarke en die Verenigde Koninkryk onbeskadig is, en meeste van dié in Holland. Toestande in Italië en Duitsland was nognie bekend nie.

9. **Sections E and F.**—In accordance with By-law 1 of the Association, the Council has rearranged the grouping of Sciences in these two Sections. In future, Section E will deal with Archaeology, Primitive Technology, Physical Anthropology; Section F will deal with Sociology, Social Anthropology, Psychology, Economics, History, Education, General Linguistics and African Languages. This arrangement was approved by a Joint Meeting of Sections E and F at the Annual Meeting in 1945.

Afdelings E en F.—Volgens Bywet 1 van die Vereniging, het die Raad die groepering van Wetenskappe in hierdie twee Afdelings anders gerangskik. In vervolg sal Afdeling E Argeologie, Primitiewe Tegnologie, Fisiese Anthropologie behandel; Afdeling F sal Sosiologie, Sosiale Antropologie, Psigologie, Ekonomie, Geskiedenis, Onderwys, Algemene Taalkunde en Bantoetale behandel. Hierdie rangskikking is deur 'n Gesamentlike Vergadering van Afdelings E en F op die Jaarlikse Vergadering in 1945 aangeneem.

10. **Annual Meeting, 1946.**—Your Council arranged a full Session of five days, July 1st-5th, in Pretoria, through the courtesy of the Pretoria City Council. This is the first normal post-war Meeting.

Jaarlikse Vergadering, 1946.—U Raad het deur die guns van die Stadsraad van Pretoria 'n volle Sitting van vyf dae, Julie 1ste-5e in Pretoria gereël. Dit is die eerste normale naoorlogse Vergadering.

11. **The New Council.**—On the basis of membership provided in the Constitution, Section 22, the number of members of Council assigned to each centre during the ensuing year should be as follows:—

Die Nuwe Raad.—Die aantal Raadslede vir elke sentrum gedurende die volgende jaar, moet, soes in die Statute, Artikel 22, bepaal, op die basis van die ledetaal as volg verdeel word:—

Transvaal:	
Witwatersrand	21
Pretoria	9
Outside Districts/Buite Distrikte	1
Province of the Cape of Good Hope:	
Cape Peninsula and District/en Distrik	6
Stellenbosch and District/en Distrik	2
East London and Port Elizabeth	1
Grahamstown, Kingwilliamstown and District/en Distrik	1
Kimberley	1
Oudtshoorn	1
Outside Districts/Buite Distrikte	1
Natal:	
Durban and District/en Distrik	3
Pietermaritzburg and Outside Districts/en Buite Distrikte	2
Orange Free State:	
Bloemfontein and District/en Distrik	2
Southern Rhodesia	1
	52

12. **Honorary Auditors.**—Messrs. Alex Aiken and Carter have again audited the Association's Accounts and deserve the thanks of the Association.

Ere-Ouditeurs.—Die firma Alex Aiken en Carter het die Rekeninge van die Genootskap weer geouditeer en die dank van die Genootskap verdien.

13. **Secretariat.**—The Council appreciates the services of the Associated Scientific and Technical Societies of South Africa in carrying out the secretarial work of the Association during the year, and in particular thanks Mr. A. J. Adams and Mr. I. M. Sinclair for their valuable assistance.

Sekretariaat.—Die Raad spreek sy waardering uit vir die dienste van die Verenigde Wetenskaplike en Werktuigkundige Verenigings as Assistent-Algemene Sekretarisse van die Genootskap gedurende die jaar, en in besonder Mnre. A. J. Adams en I. M. Sinclair bedank vir hulle waardevolle dienste.

Report of the Honorary General Treasurer for the year ended 31st May, 1946.

The Income and Expenditure Account for the year ended 31st May, 1946, shows a profit of £134 7s. 8d. as against a loss of £357 4s. 6d. last year. The reason for this improved position is a reduction in the cost of printing the Journal of Science. While the Journal Expenses last year totalled £1,353, this year they are £841—£512 less. This decrease is due mainly to a reduction in the size of the Journal and not to the cost of printing, which still remains very high and, as Members will appreciate from the delay in receiving Journals during the past two years, takes an inordinately long time to print.

A further additional charge this year was the printing of a new List of Members, which increased the Stationery and Printing Charges by £79 to a total of £108. The other items of expenditure show little change.

On the revenue side, it is satisfactory to be able to record an increase in membership fees. This increase of £89, very similar to that noted last year, shows an increasing interest in the Association which is very gratifying.

The improvement over the year is reflected in the Income and Expenditure Account, which is now £576 19s. 0d.

The continued assistance, by way of donations, towards the cost of printing the Journal, which we receive from the Union Department of Education and the City Council of Johannesburg, has to be specially remembered, because without this generous assistance the Association's major function, which is the publication of contributions received at the Annual General Meeting, would only be possible in a summarised form.

If the Association is to expand, it must find additional revenues and, at the moment, it would appear that the only way this can be done is by increasing the membership. There are no items in the Expenditure side of the account which can be regarded as extravagant or unnecessary and the only item which fluctuates appreciably is the Journal Expenses.

During the twenty-five years I have been Honorary General Treasurer, I have found that the financial position of the Association depends on the varying cost of printing the Journal. When the contributions presented to the various Sections are many, which happens when the Annual Meetings are held in the larger towns of the Union, there is an excess of expenditure over income; but, when they are held in one of the smaller towns, the reverse is more frequently the case.

The South African Association for the Advancement of Science is worthy of a much larger membership then it has at present and, as I have said previously, it will never achieve in any great measure the objects for which it was established until this has been attained.

JAS. GRAY,

Honorary General Treasurer.

Verslag van die Ere-Algemene Penningmeester vir die jaar tot op 31 Mei 1946.

Die Inkomste- en Uitgaafsrekening vir die jaar eindigende 31 Mei 1946 wys 'n wins van £134 7s. 8d. teenoor 'n verlies van £357 4s. 6d. verlede jaar. Die rede vir hierdie verbeterde toestand is 'n verlaging in die koste om die Joernaal van Wetenskap te druk. Terwyl die Joernaaluitgawes verlede jaar £1,353 beloop het is hulle vanjaar £841—£512 minder. Hierdie verlaging is veral te wyte aan 'n vermindering in die grootte van die Joernaal en nie aan die koste van druk nie, wat nog baie groot bly, en wat, soos lede deur die vertraging in die ontvangs van die Joernale gedurende die laaste twee jaar sal besef, uiters lank neem.

Verder addisionele koste vanjaar was die druk van 'n nuwe lys van lede, wat die onkoste vir skryfbehoeftes en druk met £79 vermeerder het tot 'n totaal van £108. Die ander uitgaafsitems toon min verandering.

Aan die inkomste kant is dit bevredigend om 'n vermeerdering in lidmaatskapsfooie aan te teken. Hierdie vermeerdering van £89, baie soos dié verlede jaar bemerk, toon 'n aangroeiende belangstelling in die Vereniging wat baie verblydend is.

Die verbetering deur die jaar is weerkaats in die Inkomste- en Uitgaafsrekening wat nou £576 19s. 0d. is.

Die onafgebroke ondersteuning by wyse van donasies, ten behoewe van die drukkoste van die Joernaal, wat ons van die Unie Onderwysdepartement en die Stadsraad van Johannesburg ontvang, dien spesiaal onthou te word, want sonder hierdie gulhartige hulp sou die Vereniging se hoofdoel, die publikasie van bydraes op die Jaarlikse Algemene Vergadering ontvang, alleen in verkorte vorm moontlik wees.

As die Vereniging gaan uitbrei, moet dit addisionele inkomste vind, en op die oomblik sou dit blyk dat die enigste manier waarop dit gedoen kan word is deur die lidmaatskap te vermeerder. Daar is geen items in die Uitgaafsy van die rekening wat as verkwistend of onnodig beskou kan word nie en die enigste item wat aansienlik afwissel is die Joernaaluitgawes.

Gedurende die vyf-en-twintig jaar wat ek Ere-Algemene Tesourier was het ek gevind dat die finansiële posisie van die Vereniging afhang van die veranderende drukkoste van die Joernaal. Wanneer daar baie bydraes aan die verskillende Afdelings voorgedra word, wat gebeur wanneer die Jaarlikse Vergaderings in die groter dorpe van die Unie gehou word, is daar 'n surplus van uitgawe oor inkomste; maar, wanneer hulle in een van die kleiner dorpe gehou word, is die teenoorgestelde meer dikwels die geval.

Die Suid-Afrikaanse Vereniging vir die Bevordering van Wetenskap verdien 'n baie groter lidmaatskap as wat dit teenswoordig het, en dit sal, soos ek reeds gesê het, nooit in enige groot mate die doelwitte waarvoor dit tot stand gebring is bereik nie voordat hierdie vermeerderde lidmaatskap verkry is nie.

JAS. GRAY,

Ere-Algemene Penningmeester.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Balance Sheet at 31st May, 1946.

LIABILITIES.

	£ s. d.	£ s. d.
Sundry Creditors:		
General Accounts	712 3 1	
Grants to Local Centres under Rule 35	50 7 0	
Subscriptions paid in Advance	52 11 0	
Endowment Fund	23 11 0	
		838 12 1
Library Binding and Equipment Account:		
Balance at 31st May, 1945 ..	258 5 11	
Add Interest from Library Endowment Fund ..	73 17 11	
	332 3 10	
Less Expenditure during the year	28 15 8	
		303 8 2
Income and Expenditure Account:		
Balance at 31st May, 1945 ..	442 11 4	
Add Excess of Income over Expenditure for the year ended 31st May, 1946 ..	134 7 8	
		576 19 0
		1,718 19 3
Endowment Fund		3,378 14 5
Library Endowment Fund		2,164 11 6
South Africa Medal Fund		1,712 11 2
British Association Medal Fund ..		535 16 8
		£9,510 13 0

ASSETS.

	£ s. d.	£ s. d.
Cash:		
At Bank	596 9 1	
At Post Office Savings Bank with Interest accrued ..	41 17 3	
At United Building Society, St. Andrew's Branch, with Interest accrued	987 14 0	
		1,626 0 4
Sundry Debtors:		
Library Endowment Fund ..	3 17 11	
Advertisers in Journal	70 5 0	
		74 2 11
Furniture:		
Balance at 31st May, 1945 ..	21 10 0	
Less Depreciation	4 10 0	
		17 0 0
Medals on Hand		1 16 0
		1,718 19 3
Trustees—Endowment Fund, as per separate account		3,378 14 5
Library Endowment Fund, as per separate account		2,164 11 6
Trustees—South Africa Medal Fund, as per separate account		1,712 11 2
Trustees—British Association Medal Fund, as per separate account		535 16 8
		£9,510 13 0

We have examined the books, accounts and vouchers of The South African Association for the Advancement of Science for the year ended 31st May, 1946, and have obtained all the information and explanations we have required. We have satisfied ourselves of the existence of the securities. Proper books and accounts have been kept. In our opinion the above Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of affairs of the Association at 31st May, 1946, according to the best of our information and the explanations given to us and as shown by the books of the Association as at 31st July, 1946.

Johannesburg,
29th June, 1946.

ALEX. AIKEN & CARTER,
Auditors.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Income and Expenditure Account for the Year Ended 31st May, 1946.

Dr.

		£ s. d.	£ s. d.
To Secretarial Fees			240 0 0
,, Journal Expenses		841 4 6	
Less Government Grant ..	£250 0 0		
Johannesburg Municipal Grant ..	100 0 0		
Sales, Reprints and Advrts.	214 0 0		
		564 0 0	
			277 4 6
,, Stationery and Printing ..			101 17 6
,, Postages			36 6 10
,, Expenses:			
Annual Meeting, 1945 ..		8 12 6	
Annual Meeting, 1946 (on account)		10 0 0	
			18 12 6
,, Sundry General Expenses ..			14 11 4
,, Grants to Local Centres under Rule 35—			
Witwatersrand ..	£35 13 0		
Cape of Good Hope	9 9 0		
Natal	5 5 0		
		50 7 0	
Less Grant outstanding for Natal Centre for the year ended 31st May, 1945, not claimed		4 13 0	
			45 14 0
,, Depreciation on Office Furniture			4 10 0
,, Pension—H. A. G. Jeffreys ..			90 0 0
			828 16 8
,, Balance, being Excess of Income over Expenditure for the year ended 31st May, 1946 ..			134 7 8
			£963 4 4

Cr.

	£ s. d.	£ s. d.
By Annual Subscriptions	740 14 0	
,, Arrear Subscriptions	66 11 6	
,, Associates' Fees	2 0 0	
,, Students' Fees	0 10 0	
		809 15 6
,, Interest:		
From Endowment Fund ..	133 1 6	
United Building Society, St. Andrew's Branch, Savings Account	19 7 3	
Post Office Savings Bank Account	1 0 1	
		153 8 10
		£963 4 4

We report that, to the best of our knowledge and belief and on the information supplied to us, the above account reflects a true statement of the income and expenditure of the Association for the year ended 31st May, 1946.

ALEX. AIKEN & CARTER,
Auditors.

Johannesburg,
29th June, 1946.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Library Endowment Fund.

Income and Expenditure Account for the Year Ended 31st May, 1946.

Dr.	£ s. d.	Cr.	£ s. d.
To Balance transferred to Library Binding and Equipment Account	73 17 11	By Interest received	73 17 11
	£73 17 11		£73 17 11

Balance Sheet at 31st May, 1946.

	£ s. d.		£ s. d.
Amount due to General Fund	3 17 11	Investments:	
Accumulated Funds:		£2,000 City of Johannesburg 3½% Local Registered Stock, 1965—at cost	1,970 0 0
Balance at 31st May, 1945	2,164 11 6	Cash at United Building Society, St. Andrew's Branch—Savings Bank Account	198 9 5
	£2,168 9 5		£2,163 9 5

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Endowment Fund.

Income and Expenditure Account for the Year Ended 31st May, 1946.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Interest, as per contra, transferred to General Fund	133	1	6	By Interest received	133	1	6
„ Balance, transferred to Accumulated Funds	46	0	0	„ Life Membership Subscriptions	46	0	0
	£179	1	6		£179	1	6

Balance Sheet at 31st May, 1946.

	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.
Accumulated Funds:							Investments in hands of Trustees:						
Balance at 31st May, 1945 ..	3,332	14	5				Cape Town Municipality 3¾% Stock—No. 145	1,150	0	0			
Add—Amount transferred from Income and Expenditure Account	46	0	0				Cape Town Municipality 4% Stock—No. 140	300	0	0			
				3,378	14	5	Cape Town Municipality 5% Stock—No. 68	240	0	0			
							Cape Town Municipality 5% Stock—No. 120	800	0	0			
							Port Elizabeth Municipality 3½% Stock—No. 9	100	0	0			
							Cape of Good Hope Savings Bank	765	3	5			
											3,355	3	5
							Amount due from General Fund ..				23	11	0
				£3,378	14	5					£3,378	14	5

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The British Association Medal Fund.

Dr. **Income and Expenditure Account for the Year Ended 31st May, 1946.** **Cr.**

	£ s. d.		£ s. d.
To Balance transferred to Accumulated Funds	18 14 2	By Interest received	18 14 2
	£18 14 2		£18 14 2

Balance Sheet at 31st May, 1946.

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
Accumulated Funds:			Investments in hands of Trustees:		
Balance at 31st May, 1945 ..	517 2 6		£450 Union of South Africa 3½% Local Registered Stock, 1948/58	450 0 0	
Add—Amount transferred from Income and Expenditure Account	18 14 2		Post Office Savings Bank	85 16 8	
		535 16 8			535 16 8
		£535 16 8			£535 16 8

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

South Africa Medal Fund.

Income and Expenditure Account for the Year Ended 31st May, 1946.

Dr.	£ s. d.	Cr.	£ s. d.
To Expenses	8 0 0	By Interest received	50 2 1
„ Balance, transferred to Accumulated Funds	42 2 1		
	£50 2 1		£50 2 1

Balance Sheet at 31st May, 1946.

	£ s. d.	£ s. d.		£ s. d.
Accumulated Funds:			Investment in hands of Trustees:	
Balance at 31st May, 1945	1,670 9 1		Fixed Deposit, South African Permanent Mutual Building and Investment Society	1,712 11 2
Add—Amount transferred from Income and Expenditure Account	42 2 1			
		1,712 11 2		
		£1,712 11 2		£1,712 11 2

Report of the Honorary Librarian for the year ended 31st May, 1946.

Verslag van die Ere-Bibliotekaris vir die jaar geëindig 31 Mei 1946.

The Association's Library is housed in the Library of the University of the Witwatersrand, Johannesburg. The collection includes about 4,000 volumes, and 182 different titles are received currently.

Die Genootskap se Biblioteek word in die Biblioteek van die Universiteit van die Witwatersrand, Johannesburg, gehuisves. Die versameling bevat omtrent 4,000 bande en 182 verskillende titels word lopend ontvang.

Exchange of Publications.—During the year the following new names have been added to the exchange mailing list:—

Ruiling van Publikasies.—Gedurende die afgelope jaar is die volgende nuwe name by die omruilingslys bygevoeg:—

Cordoba. Universidad nacional.
Florida academy of sciences.
Société d'études Camerounaises.

During the years 1939-1945, the supply of journals from overseas dwindled considerably. A high proportion of the societies and institutions from which publications had previously been received regularly were in enemy and occupied territories, and in the United States; publications were often held back until the shipping situation improved. Since the termination of hostilities, several of the societies and institutions have written to request the resumption of exchange relations, and have sent complete sets of their publications issued during the war years. Publications are now again being received currently from the following:—

Gedurende die jare 1939-1945, het die toevoer van oorsese tydskrifte aansienlik verminder. 'n Groot deel van die vereniginge en institute van wie publikasies vantevore gereeld ontvang is, was in vyandelike en besette gebiede, en in die V.S.A., is publikasies dikwels teruggehou totdat die verskepings-posisie verbeter het. Sedert die staking van vyandelikhede het verskeie van die verenigings en institute geskryf om te vra of die hervatting van ruilings weer kon begin, en het volledige stelle van hulle publikasies gedurende die oorlogsjare gestuur. Publikasies word nou weer lopend van die volgende ontvang:—

Belgium:

Jardin botanique de l'État (*Bulletin*).
Musée du Congo Belge (*Annales*).

France:

Commission internationale des industries agricoles (*Bulletin de l'Association de chimistes*).
Revue géneral des sciences.

Holland:

Leiden. Sterrewacht (*Annalen*).
Nederlandsche dierkundige vereeniging (*Archives Néerlandaises de zoologie*).
Wiskundig genootschap (*Nieuw archief voor wiskunde; Wiskundige opgaven*).

Sweden:

Lund. University Library (*Acta Universitatis Lundensis*).

Svenska vetenskapsakademien (*Arkiv for botanik; Arkiv for kemi mineralogi och geologi; Arkiv for matematik astronomi och fysik; Arkiv for zoologi; Handlingar*).

Uppsala. Royal University Library (*Bulletin of the Geological Institute*).

Switzerland:

Naturforschende Gesellschaft (*Vierteljahrsschrift; Neujahrsblatt*).

Société de physique et d'histoire naturelle (*Compte rendus; Mémoires*).

U.S.A.:

California. University (*Publications*).

Connecticut academy of sciences (*Transactions*).

Franklin institute (*Journal*).

Iowa. State university (*Studies in natural history*).

New York. Academy of sciences (*Annals; Transactions*).

U.S. Dept. of agriculture (*Agricultural statistics*).

South African Journal of Science.

A complete set of the *Journal* from volume 1, 1903 to date, except for a few numbers which are not available, has been presented to the Library of the Royal Empire Society to replace the set which was lost when the Library was destroyed by enemy action.

The Association's Library continues to store the stock of the *Journal* and to supply individual volumes and parts for which requests or orders are received.

'n Volledige stel van die *Journal* vanaf deel 1, 1903 tot op datum behalwe vir 'n paar nommers wat nie beskikbaar is nie, is aan die Biblioteek van die Royal Empire Society geskenk om die stel te vervang wat verlore gegaan het toe die Biblioteek weens vyandelike optrede vernietig is.

Die Genootskap se Biblioteek bewaar nog steeds eksemplare van die *Journal* en verskaf indiwiduele bande en dele waarvoor aanvrae of bestellings ontvang word.

Donations from the following are gratefully acknowledged:—

Geskenke van die volgende word dankbaar erken:—

Mr. J. Collins: *South African Journal of Science* 1903-1908, 1941; *British Association. Report* 1905; *Science in South Africa.*

National Institute of Economic and Social Research: *Register of research in the social sciences.*

Mrs. J. F. Solly: *South African Journal of Science*, 3 numbers; *Excavations at Colliston Park.*

South African Air Force. Meteorological Headquarters: *Weather on the coast of Southern Africa.*

Dr. J. B. Robertson: *South African Journal of Science*, 1919-1944; Royal institute of chemistry. *Journal and proceedings*, 1919-1945; South African chemical institute. *Journal*, 1919-1944.

Transvaal Museum: Broom, R., and Schepers, G. W. H. *S. African fossil ape men.*

C. R. van der Merwe: *Soil groups and sub-groups of South Africa*, by C. R. van der Merwe.

Miss M. C. K. Williamson: *South African Journal of Science*, 1920-1941

Accessions to Serial Publications, 1945-1946.

Aanwinste tot Periodieke Publikasies, 1945-1946.

Academy of natural sciences of Philadelphia. Monographs. 3, 1939+.

Association des chimistes. Bulletin. 57, 1940+.

California academy of sciences. Occasional papers. 20, 1934+. Proceedings. 4th ser. 20, 1937+.

Indian science congress. Proceedings. 31, 1944+.

Science comment (British council) 3, 1944+.

Société d'études Camerounaises. Bulletin. 1, 1935+.

Western Australia. Dept. of mines. Mineral resources. Bulletin. 1, 1944+.

For a Catalogue of serial publications in this Library, and Supplement, see this *Journal*, vol. 30, p. xxv-xxix, and vol. 34, p. xxxiv-xxxvii. Subsequent accessions are listed in the Annual Report. Holdings appear also in the *Catalogue of Union Periodicals* and forthcoming Supplement.

Vir 'n Katalogus van periodieke publikasies in die Biblioteek, en Supplement, sien hierdie *Journal*, Band 30, b. xxv-xxix, en Band 34, b. xxxiv-xxxvii. 'n Lys van latere aanwinste word in die Jaarlikse Verslag gegee, en 'n volledige lys verskyn ook in die *Catalogue of Union Periodicals* en daaropvolgende byvoegsel.

P. FREER,

Hon. Librarian/Ere-Bibliotekaris.

University of the Witwatersrand/Universiteit van die Witwatersrand, Johannesburg,

3rd June/3 Junie 1946.

In Memoriam.

ARTHUR W. ROGERS, Sc.D., F.R.S., F.G.S.

Arthur Rogers, who died at Mowbray on June 23rd, 1946, was born in Somersetshire on June 5th, 1872, and graduated with honours from Christ's College, Cambridge.

Appointed assistant geologist to the Geological Commission of the Cape of Good Hope, Cape Town, in 1896, he later became its chief, and subsequently director of the Geological Survey of the Union, Pretoria, from 1916 to 1932. Associated in the beginning with the late Prof. E. H. L. Schwarz during those early years, he carried out extensive surveys of little known parts of the Cape Province, particularly in the north and north-west, making many novel geological and geographical discoveries. His interest in the Kalahari was extensive. In the Transvaal his chief work, apart from administrative duties, lay in the detailed mapping of the Heidelberg and Klerksdorp Goldfields. Under his steadfast lead a geological organisation was built up of international repute.

From among his many and varied writings, official reports and addresses must specially be mentioned "An Introduction to the Geology of Cape Colony" (1905) the first text-book of its kind, and his inspiring and detailed account of "The Pioneers in South African Geology and their Work" (1937), one worthy of reperusal in these days of fleeting tendencies.

Rogers will always be remembered as a modest scientist of happy disposition, high principles and repute, ever ready to do justice to the work or views of others, and his opinion was therefore prized. After his retirement to Mowbray in 1932 he became deeply interested in microscopical research, particularly into the diatomaceous deposits, a pursuit which he was able to pursue even after serious illness had affected his bodily activities. Such studies he was fortunately able to include in a memoir, not yet printed.

Rogers was a foundation member, a member of council for many years, president of Section B in 1910 and president of this Association in 1922, though a rare contributor to the Journal. Belonging to, or honoured by, many learned societies, he was a fellow of the Royal Society of London, president of the Geological Society of South Africa (1915), of the Royal Society of South Africa (1934-1935) and of the International Geological Congress (1929). He was awarded the Bigsby, Wollaston, South Africa, Scott, and Draper Medals, as well as an Hon. D.Sc. degree from the Universities of Cape Town and Witwatersrand.

South African Journal of Science, *Vol. XLIII, pp. 1-35, July, 1947.*

A CRITICAL EXAMINATION OF THE EVIDENCE RELATING TO THE DISCOVERY OF THE MAIN REEF SERIES OF AURIFEROUS CONGLOMERATES ON THE WITWATERSRAND, ON PORTION OF THE FARM LANGLAAGTE, BELONGING TO G. C. OOSTHUIZEN, IN 1886

BY

The Hon. Mr. Justice F. E. T. Krause.

A concise summary of the Presidential Address to the South African Association for the Advancement of Science, delivered at Pretoria, 1st July, 1946.

Owing to the continued shortage of paper and the high costs of printing, it is possible only to publish in the Journal a concise summary of my Presidential Address relating to the Discovery of the Main Reef. Since then some additional facts have come to my notice, and these I have incorporated, thereby presenting an up-to-date picture of all the relevant available evidence.

I propose, in the summary of the evidence, to confine myself strictly to such facts as are beyond all dispute, and which can be verified by reference to official records and other reliable contemporary writings—"Hearsay evidence" and "canteen gossip" will be disregarded, in fact strictly rejected. The correctness of the inferences to be drawn from established facts will be left to the logical judgment of the reader.

I wish to make it quite clear that, in this paper, I am not, in any way, concerned with the first discovery of gold in the Transvaal, nor do I intend to deal with the activities of the Gold-seekers in the Witwatersrand area before 1886. My sole object will be, on the evidence tendered, to decide who was the real discoverer of the Main Reef Series of auriferous Conglomerates on Langlaagte in 1886, which eventually led to the proclamation of the Witwatersrand Goldfields. It is necessary to emphasise this fact, as many persons have misunderstood the scope of my examination, and this has led to a great deal of confused thinking and ill-judged comments.

Public interest in identity of Discoverer. Members of the "Pioneers of the Transvaal Goldfields Association" enthusiastic partisans of George Walker.

Public interest in the identity of the Discoverer of the Main Reef series on the Witwatersrand was especially aroused, when preparations were being made to celebrate the fortieth anniversary of the proclamation of the Witwatersrand Goldfields in 1926.

Certain members, especially of the "Pioneers of the Transvaal Goldfields Association" became enthusiastic partisans of

the claim of a miner named George Walker, and it was as a result mainly of their activities that wide publicity was given to the matter. In Appendix 3 will be found particulars of the activities of the members principally concerned.

Controversy becomes acrimonious. Number of claimants increases. Monuments Commission appoints fact-finding Committee in December, 1938.

The number of claimants and of the partisans of deceased gold seekers gradually increased as the honour of being declared the discoverer became a coveted prize. Hedley Chilvers, in his book "Out of the Crucible" (1929) correctly summed up the position, as follows:

> "For many years there has been discussion as to who was the real discoverer of the Witwatersrand Goldfields—discussion which has sometimes become somewhat acrimonious. The bitterness of the controversy is comprehensible only on the ground that the disputants recognised clearly how immense was the discovery, and how signal, therefore, the honour of making it. It is but natural that there should be many claimants." . . .

To settle this controversy the Government was appealed to, and "The Commission for the preservation of Natural and Historical monuments, relics and antiques" at its meeting, held at Kimberley, in December, 1938, resolved to appoint a "fact-finding" Committee to enquire into the matter.

The most essential instruction given to the Committee is contained in Paragraph (2) of the terms of reference, which reads as follows: "(2) The Discovery of the Main Reef Group of Conglomerates, by whom, when, and where."

The Committee commenced its enquiry in February, 1939, and after having heard and considered the evidence tendered and collected, first published its Findings in typescript in February, 1940.

With reference to paragraph 2 of the Terms of Reference, these findings were as follows:

"7. That the Main Reef Group of Conglomerates was first found on G. C. Oosthuizen's part (Portion "C") of the farm Langlaagte, shortly before the end of March, 1886. This led directly to the prospecting contract of the 12th April, 1886.

"8. That this find was accidental. It was made by George Walker, probably in association with George Harrison, but there is no record of either of these men having had assays made or milling done on the Conglomerate on which they subsequently pegged contract discoverer's claims."

Accepted meaning of the words "Discovery" and "Discoverer".

Accuracy in the use of terms is essential in all scientific investigations. The Committee fully realised this, and on page 8 of their first Printed Report, published in 1941, the connotation of the words "Discovery" and "Discoverer" is set out as follows:

> "It is obvious that as long as such widely divergent interpretations of the term 'discovery' are current, it is impossible to reach finality on the question. The Committee, therefore, had to determine and to define as precisely as possible, what it was expected to examine and report upon.
>
> "The Minister who originally recommended the enquiry for the Government was the Hon. F. C. Sturrock, at the time acting Minister for the Interior. In an interview with representatives of Rand Pioneer bodies, who were asking for such an enquiry, Mr. Sturrock was reported to have said: 'I take it that your object is to decide who was the first man to prove and open up the Main Reef, and not those who claim to have picked up an odd bit of rock here and there?' (*Rand Daily Mail*, 11th March, 1938.)
>
> "The Committee has interpreted its terms of reference in the spirit of this remark. It assumes that mere reports of the finding of gold—without the least attempt to exploit that find, are totally devoid of any practical result—while they may be of some academic interest, cannot reasonably be regarded as a subject for official investigation. It, therefore, proposes to limit its enquiry strictly to such discoveries as led eventually to actual exploitation. It adopts the view that the word "discovery" as used in its terms of reference and applied to the finding of gold-bearing reefs, means, and should be taken to mean, not merely the act of finding or exposing to view such reefs, but also the disclosure or publication of such finds, and the consequent opening up of such reefs—leading eventually to actual exploitation.
>
> "In this sense it proposes to use the term 'discovery' and 'discoverer' throughout this report."

The meaning given to these words and adopted for use throughout the report should be carefully kept in mind, because, in considering and weighing the evidence accepted and relied upon by the Committee, the reader will be invited to say whether Walker's alleged find is or could be included in the terms of this definition, especially in view of Walker's own declaration that he had kept his discovery secret—even from his pal, Harrison.

The 1941 printed report of the Committee stresses another important point, namely, that the "oral evidence" submitted by the witnesses regarding happenings more than fifty years before could not be accepted uncritically. It was for this reason, that the evidence of Walker and of Honeyball, regarding the

date of the alleged discovery of the Main Reef on Sunday, the 7th February, 1886, was rejected. The reason given was, that the claim is "supported" only by the statement made by two old men many years after the event, "and is not borne out by any contemporary documentary evidence". It will be pointed out subsequently that, in other respects, the Committee accepted such "oral evidence" as conclusive, whereas "contemporary documentary evidence and even official records", were rejected as valueless.

The Three Georges. Langlaagte divided into four portions. Main Reef discovered on Portion C. belonging to G. C. Oosthuizen.

The story of the discovery revolves round three persons—(in later years called the "three Georges"), namely: George Walker, George Harrison and George Honeyball (still alive and born in 1857).

George Walker and George Harrison had been gold diggers in the Barberton district for some years and were mates. After a visit to friends down South they accidentally met, and decided to return together to their former gold-digging haunts in Barberton. This was in January, 1886. On reaching Mulder's Drift, however, they heard that the Struben Bros. were looking out for a miner. Walker got the job and started work at the Confidence Mine at Wilgespruit, and remained there, according to his own statement, for four months. Harrison proceeded to Langlaagte and there secured a contract from Hendrik Oosthuizen to build a house for him. The farm Langlaagte, in 1886, had been divided into four approximately equal portions of 560 morgen each—marked A, B, C, D, from West to East. Portion "D" belonged jointly to Hendrik Oosthuizen and his mother, the widow Petronella Oosthuizen, and portion "C" belonged to Gerhardus Cornelis Oosthuizen. It was on this portion that, in 1886, the Main Reef was first discovered.

George Honeyball had a small Smithy on the Widow Petronella Oosthuizen's portion D. He called her "Tante" or Aunt—but was in no way related to her. He had been living there for about 18 months prior to 1886, and being in poor circumstances, obtained free board and lodging from the generous widow. After the proclamation of the Goldfields, Honeyball vanished from the scene and was later discovered, on 30th March, 1930, at Pienaar's River, where he had a small Blacksmith's shop. He was then living in abject poverty.

On the 21st April, 1930, Mr. McLea presented him with a money gift from some anonymous donors, and, since then, he has also been receiving, annually, a small pension. George Walker had also obtained some £400 between 1912 and 1919 from the Miners' Phthisis Board on a plea of poverty and of being the oldest miner on the Rand, but made no claim of discovery

of the Main Reef. McLea, however, who found him in abject poverty in Krugersdorp in 1924, obtained for him a pension of £200 a year from the Chamber of Mines. It will thus be seen that both Walker and Honeyball had strong financial motives in telling and in adhering to their account of the alleged discovery. Honeyball's account is, in fact, only an echo of Walker's. Both accounts were edited by J. L. P. Erasmus. The Report, however, disregarded the sound rule relating to motive when judging of the credibility of witnesses but stressed the vagaries of the human memory alone, and was not even consistent in doing so. Walker, after his discharge from the Strubens, proceeded to Langlaagte to pick up his pal, Harrison, with a view to continuing their journey to Barberton, and it was after this visit—which could not have been much earlier than April, 1886—that gold-bearing rocks were found on Langlaagte which attracted the activities of the gold-seekers to that area. There can be no doubt but that Harrison was on friendly terms with the Oosthuizens and that Walker was a comparative stranger to them. The natural inference is, that it was Harrison who would have succeeded, in these circumstances, in negotiating for prospecting rights with the owner, even before Walker arrived upon the scene.

The undisputed evidence, as it developes, will incontestably prove, that in all subsequent dealings with the owner, G. C. Oosthuizen, and having regard to all the official steps taken to proclaim Langlaagte, only Harrison is mentioned as the prospector, whereas Walker's name does not appear in the picture at all. This is a most significant fact which cannot be overlooked. It strongly supports the above inference.

Having regard to the movements of Harrison the following extract from the typewritten Report of 1940, but omitted from the Printed Report of 1941, is important:

> "Harrison seems to have disappeared after a few more months from the ken of the rapidly growing Witwatersrand. This fact may explain why in after years stress was laid on the part played by Walker, whom men knew, and not on that played by Harrison who was 'out of sight and so out of mind'. In spite of statements made by living men, who claim to have known both the 'Georges', that Walker was the leader of that little band of two, in our opinion it is not possible to credit one to the exclusion of the other with having first found and prospected—however lightly—the Main Reef Group of Conglomerates."

It is possible, that Harrison, after the proclamation, continued his journey to Barberton.

The reasons for omitting the above from the Printed Report are not given. Two facts, however, emerge from the above statement—firstly, that the statements of living men, who knew

both the Georges, was then not accepted; and, secondly, that a joint Discovery was the considered opinion of the Committee at that time. Again, the reasons for the subsequent "volte face" are unknown.

Researches of Ethel L. Gray and James Gray.

For many years before and during the period of this enquiry Ethel L. and James Gray had been making intensive researches into the Official Archives and other contemporary writings having reference to the Discovery of the Main Reef and the mining activities in connection therewith. All the material collected by them was placed unreservedly at the disposal of the Committee. On page 6 of the Report a well-deserved tribute is paid to Mrs. Ethel L. Gray as follows:

> "Here a special tribute should be paid to Mrs. E. L. Gray for the most valuable researches she has done in the Archives and elsewhere, the fruits of which she placed unreservedly at the disposal of the Committee. This saved the Committee an enormous amount of time and labour."

In 1937 Jas. Gray had published his work on "Payable Gold", based upon Mrs. Ethel L. Gray's work in the State Archives, containing the documentary history of the discovery of the Main Reef with 74 reproductions of documents, maps and other matter, and in July, 1940, after some years had been spent in analysing the records of the Government Mining Departments and of the Law Courts with the relative correspondence, Ethel L. and Jas. Gray published their "History of the Discovery of the Witwatersrand Goldfields", a sequel to "Payable Gold", containing 209 plates of photographic reproductions of all original documents from the State Archives, the Law Courts and the Government Mining Departments relevant to the enquiry.

I shall, where necessary, refer to these documents by the numbers of the plates given to them. This documentary evidence is of undisputed value. Where contemporary facts are recorded in official and other documents, it would be the height of folly to rely for the proof of any fact upon "canteen gossip", "hearsay evidence" or the vagaries of the human memory, so many years after the events have happened. Unfortunately that is just what the Report has done, and, curiously enough, the Historical member of the Committee candidly admits this, and even attempts to justify it. After a careful weighing of the evidence revealed by the official records and other contemporary documentary evidence, Ethel L. Gray and James Gray came to the conclusion hereunder set out, radically differing from the findings arrived at by the Committee of Enquiry, namely:

> "In conclusion we have to state, without equivocation, that George Harrison, the Australian gold digger, was the discoverer of the Main Reef Group of Conglomerates. He

was recognised in Law, received the promised reward from the Government—Discoverer's Rights—and all the official records, supported by legal evidence, uphold this—the only feasible conclusion; there exists no evidence that can confute this statement, and no matter how authoritative the Report of the Committee may appear, it cannot be allowed to confuse the issue without comment."

On page 113 they write:

"By means of illustrations from a defended action in the Court of the Special Landdrost, on appeal to the Diggers' Committee and by the arguments used by Counsel having an intimate knowledge of the Gold Law under which the action was contested, it has been proved that George Harrison received Claim No. 19 as a reward for his discovery of the Witwatersrand Gold Fields, according to Article 9 of the Gold Law. This can only lead to one conclusion: George Harrison was the Discoverer of the Witwatersrand Gold Fields."

"A REVIEW" BY ME, JUNE, 1942.

Having been approached to critically examine the evidence, on the one hand that accepted by the Committee and on the other hand that relied upon by the Grays, I published, in June, 1942, a paper entitled "A Review" in which, after careful examination, I expressed the opinion that the Grays were fully justified in coming to the conclusions set out in their book, and that the findings of the Committee, with reference to George Walker, could not be supported.

A copy of my "Review" was sent to the members of the Historical Monuments Commission.

I pointed out that, the Committee had, in my opinion, wrongly accepted, as the basis of its conclusions, "Hearsay Evidence", which, according to experience and the dictates of common sense, was valueless in arriving at the truth, and had, quite unjustifiably, disregarded and rejected the official records and other documentary evidence.

Prof. Leo Fouchè, the co-opted Historical member of the Committee defends the acceptance of "Hearsay Evidence": The issue narrowed down to Hearsay Evidence on the one hand and Official Records and contemporary documentary evidence on the other hand.

Prof. Leo Fouchè, the co-opted historical member of the Committee, thereupon addressed a letter to me, dated the 13th July, 1942, in which he writes, *inter alia*, as follows:

"However . . . I except strongly . . . even violently to your pleading and deny its very foundation; hearsay evidence for historians, is evidence. . . . History does not

recognise the rules of legal evidence—only the sound common sense underlying . . . the (tested) hearsay evidence in this case is overwhelmingly in favour of a joint discovery of the two Georges."

On the 16th July, 1942, I wrote in reply to the above admission about Hearsay Evidence, *inter alia*, as follows:

> "The controversy is narrowed down to the following crisp issue: Hearsay Evidence and its value on one side—and official records and other documentary evidence and their value on the other side. . . . The controversy is of great public interest, and I am sure there can be no valid objection, should occasion arise, to take the public into one's confidence by presenting the two points of approach—shall we call it "The Historian's conception and valuation of the evidence on the one side, and the lawyer's on the other side."

Again, on the 21st July, 1942, I wrote, *inter alia*:

> "All this laboured explanation of the Historian's method of research is really quite irrelevant—we are not concerned with the methods employed but with the evidence that was accepted. The simple issue is that you admit that the Committee based Walker's claim to being the Discoverer solely on "Hearsay" or (tested) hearsay and that it was justified in coming to that conclusion, because for Historians "Hearsay is evidence". On the other hand, the official records and other documentary evidence, supported by two decisions of Courts of competent jurisdiction, and even Walker's own signature to a petition, prove incontestably that George Harrison was recognised and rewarded as the Discoverer; the intelligent public will now have to decide which contention is the correct one."

Hearsay may offer an impulse or a starting point for scientific research, but its acceptance as evidence is a negation of both science and law.

I desire to emphasise this fact that no member of the Committee has, to my knowledge at any time, publicly questioned or disputed the thesis propounded by Prof. Leo Fouchè.

NEW FORMULA ADOPTED.

The Committee of Enquiry, thereafter, in February, 1945, reconsidered and amended its Findings and adopted the following new formula:

> "Taking cognisance of representations which have recently been made to it with regard to its Findings as published in "The Discovery of Gold on the Witwatersrand" the Commission reaffirms its conclusion, that it was an association between Walker and Harrison which led to the discovery of payable gold on the Witwatersrand, recognises

that its Finding in par. (8) on page 49 of the Report as printed may have minimised the contribution which Harrison made to the discovery, and recommends, that on the available evidence no attempt should be made to assess the respective contributions made by these two pioneers, jointly, to the discovery of the Main Reef Group of Conglomerates."

This new formula was considered to be and is unsatisfactory, as it fails to finally settle the controversy and leaves the identity of the actual discoverer still undecided.

I, thereupon, requested the Monuments' Commission to grant me permission to peruse and examine the evidence still available, which had been tendered to the Committee, and which it had accepted and relied upon, in arriving at its conclusions. In November, 1945, the Commission readily and courteously acceded to this, my request.

I publish in May, 1946, "A Critical Examination of the Evidence".

Having carefully examined the evidence accepted by the Committee of Enquiry, as also the official records and other contemporary documentary writings relied upon by the Grays, as well as such further evidence as was tendered and could be collected, I published on the 31st May, 1946, a paper entitled "A Critical Examination of the Evidence relating to the Discovery, etc." in which I reaffirmed my opinion previously expressed, namely, that the Grays were justified in the conclusion they had arrived at, that George Harrison, a licensed prospector, was recognised by the Government as being the Discoverer of payable gold on Langlaagte, and not George Walker, and that George Harrison had received as a reward for his discovery, a claim No. 19, which was named and registered, in terms of Article 9 of the Gold Law, as a "*Zoekersclaim*".

A copy of this paper has been presented to the Library of the Association. It contains two appendices in which I have collected and published all the evidence or relevant extracts therefrom which would enable the impartial critic, after examination, to form his own conclusions.

My Presidential address to the Association on the 1st July, 1946, was a summary of that Paper.

Resolution of the Monuments' Commission of the 25th September, 1946.

Since delivery of my Presidential Address and presumably in consequence of the criticism therein made, the Monuments Commission reconsidered its findings, and, on the 1st October, 1946, wrote to me to the effect that, at Vryheid, on the 25th September, 1946, the Commission had resolved to adhere to the conclusion it had previously arrived at—namely:

"That on the available evidence no attempt should be made to assess the respective contributions made by those two pioneers (Harrison and Walker), jointly, to the Discovery of the Main Reef Group of Conglomerates, and therefore resolves to take no further action in the matter *as* no *new* relevant evidence or facts have been brought to its notice."

It will be appreciated that, this resolution leaves the controversy still in the air. The Commission just cannot make up its mind. Furthermore, and this the serious part of the case, the Commission failed to realise and appreciate, that it was *not* a question of "bringing *new* relevant evidence or facts to its notice" but the consideration of the crisp issue, whether "Hearsay Evidence" should have formed the basis of its findings and what weight was to be given thereto, or whether official records and other contemporary documentary evidence should have been relied upon, and not have been disregarded and rejected, as was done. That being so the criticism is justified, that the resolution is a clumsy attempt to evade the issue and to draw a red-herring across the trail.

After the above introductory observations and the history of the development of the controversy, the reader will be able to follow the analysis of the relevant evidence which has been tendered, and will then be in a position to form his own conclusions.

RULE WITH REGARD TO HEARSAY EVIDENCE.

It will be remembered that Prof. Leo Fouché, in his letter, propounds this absurd paradox, namely: "History does not recognise the rules of legal evidence—only the sound common sense underlying". If one accepts the sound common sense underlying the rules, by what mental gymnastics is one justified in rejecting the rules evolved. He also says "Hearsay Evidence for Historians is evidence".

A person, however, can only testify to facts within his own knowledge, and consequently he cannot be permitted to testify to information given by others, however, worthy of credit they may be. The danger, if this were allowed, is:

(1) The irresponsibility of the original declarant (he may have been joking, bluffing or deliberately misleading).

(2) The depreciation of the truth by a process of repetition; and

(3) The opportunities which are afforded for fraud by admitting it apart from other considerations.

In a Court of Law, "hearsay evidence" is excluded: (1) because of the absence of its being given on oath and (2) because it is impossible to test its veracity by cross-examination. What Walker, therefore, told various people, namely, that he acci-

dentally stumbled over an outcrop of the Main Reef is not proved to have happened by his repeating this to Struben, Honeyball, Pritchard and to his canteen chums, and these persons have now come along and said that Walker had told them so. The truth of the story still rests on what credence should be given to Walker's story. Was it true, or was he bluffing, or was he cadging for free drinks in canteens, as Pritchard testifies, or did he vaingloriously desire to enhance his own importance, or even at a later date, because the honour of being declared the discoverer was a coveted possession, or because it had then acquired a financial advantage, and had in fact brought him a pension of £200 a year, when he was living in abject poverty? If the reader will bear these observations in mind, it will not be difficult to assess the evidence tendered at its true value.

The Hearsay Evidence accepted by and relied upon by the Committee.

The Committee, in its published Report, at page 36, discloses the evidence which formed the very foundation of its findings as follows:

> "We can now turn to the consideration of the respective claims of Walker and Harrison. One piece of evidence among all others should be emphasised as it is considered by the Committee to be of special importance: It is the statement made by Fred Struben at latest in October, 1887, just over a year after the event, when his memory was still fresh, that 'Walker . . . found on Langlaagte, what is now known as the Main Reef'. He made no mention of Harrison. This statement was fully and emphatically confirmed in the evidence given to the Committee by witnesses who were on the Rand at the time of the discovery, such as Honeyball, and more especially, H. J. Liebenberg, or who came shortly after, such as W. H. Auret Pritchard. These witnesses spoke both from their personal knowledge and that of their contemporaries. All this body of evidence is further corroborated by the statements of Willem Oosthuizen and others. In view of this, the Committee is of opinion that Walker should have the first place as the discoverer of the Main Reef on the Witwatersrand Gold Fields."

The quotation "Walker found on Langlaagte what is now known as the Main Reef" is copied from E. P. Mathers' book, published in October, 1887, entitled "The Gold Fields Revisited", and also repeated in Fred Struben's "Memos of the Early History of the Rand", published in 1896. The full statement of Fred Struben was, however, omitted, because this is what he said: "On one of their (i.e. Walker and his friend) rambles about the property, they discovered the Main Reef, so that to Walker and his friend is due the credit for the discovery of it." The added remark, therefore, namely: "He made no mention

of Harrison" is inexcusable and entirely unjustified. In a Court of Justice a witness who reveals only half the truth would be open to severe censure.

A. Struben's Letter of 22nd July, 1946.

"As Walker had emphatically stated, that he had kept his alleged find a secret, and as there was no reliable evidence to prove *who* had told Struben that Walker had found the Main Reef on Langlaagte, inquiries were made by me of A. Struben, son of H. Struben, who had interested himself in the question and had written a detailed account of the incidents of those early days, whether he could ascertain from the Struben correspondence and documents 'who' had told Fred Struben this story. On the 22nd July, 1946, A. Struben wrote as follows:

> "'Your P.2 (1). Even if Walker kept his find a secret at first, he evidently blabbed later and may possibly have shown his former employers his find. I have no proof. Your p.3 second par.: Who told F. Struben et seq.? I have found no evidence that Fred Struben was told by anyone'."

Several Versions of Fred Struben about Walker's alleged discovery.

It should be mentioned that in 1903 F. Struben, personally, submitted a rough sketch plan of Langlaagte, published in the "Mining and Industrial Magazine" on the 11th September, 1936. On this plan he says: "X2 indicates the spot where the Main Reef was first struck early in 1886 by Walker and his friend on the farm Langlaagte."

Again on the 24th June, 1903, H. H. Webb, in his valedictory address to the S.A. Association of Engineers wrote as follows:

> "Mr. Fred Struben informs me that it was shortly after crushing the Bird Reef, that a former employee, named Walker, wanted to join a friend, who at the time was building a cottage for the widow Oosthuizen, then owner of the farm Langlaagte. It seems that while quarrying the stone for the erection of this building from the sandstone outcrop, they came across a vein. . . . This subsequently proved to be what is now known as the Main Reef leader. . . ."

It should be observed; that the "stumbling over an outcrop in the long grass" is now replaced by "quarrying for stone".

There can be no doubt but that Fred Struben gave several conflicting versions of the alleged discovery. The Report emphasises that, "this statement of Struben's was a piece of evidence of special importance". It was, of course, no evidence at all, and was absolutely valueless to establish the truth of Walker's story.

Godfray Lys's version of the Story—"Rand Daily Mail," 22nd September, 1906.

Godfray Lys, again in "The Rand Daily Mail" of the 22nd September, 1906, gives the following version:

> "The Main Reef was discovered early in 1886, by two men, Messrs. Honeyball and Walker, whom we had occasion to discharge from our employ. Upon leaving us they went to Mrs. Oosthuizen's farm at Langlaagte, and there undertook to build her a new house. When quarrying for the stone for this house they came across the conglomerate and saw specks of what they took to be gold. They brought some of the quartz to us, and we tested it all at the Mill, finding as a result that it was gold-bearing rock."

On enquiring of Mr. A. Struben, whether George Honeyball had ever been employed by the Struben Bros. he wrote to me on the 12th August, 1946:

> "Honeyball: I find no evidence that this man was at any time employed by the Strubens. MacDonald P.236 stated that he had merely paid a cursory visit to Struben's Mill."

Honeyball in his statement, also says, that he had only met Lys on his visits to the Confidence Mine.

There can be no doubt but that Lys's evidence cannot be relied on. H. J. Liebenberg in his evidence says Honeyball was just a hanger-on (een los kerel).

On the 22nd July, 1946, Mr. A. Struben wrote to me:

> "Your P.3 (2): The Honeyball-Lys yarns given many years after the events are supposed to have occurred, appear to me fairy tales."

I should add, that in a declaration, dated 10th October, 1935, given to J. L. P. Erasmus, Godfray Lys flatly contradicts the story he told to "The Rand Daily Mail" in 1906.

It is necessary, before dealing with the stories of the other witnesses mentioned, who are said to "fully and emphatically confirm" the statement of Fred Struben, to pause for a moment and ascertain what stories George Walker himself told of his alleged discovery.

Walker gave several contradictory accounts of his find (this the Committee admits)—they all, however, agree in one respect, namely, that it was in February, 1886, that he stumbled over an outcrop, panned it and found it to be gold-bearing.

George Walker's own version in writing given to F. J. du Toit in 1924 and published in "South Africa" on 3rd October, 1936.

One of Walker's accounts is in his own handwriting. It was in pencil and was given to F. J. du Toit in the beginning of 1924. It was subsequently published, on the 3rd October, 1936, in the paper "South Africa".

The material portions of his account are as follows:

"When I left Mr. Struben I went to see if Harrison had finished building the house (for Hendrik Oosthuizen). I decided to help him to get the work finished, so a portion of February, 1886, we spent on the farm. One Sunday morning in that month I was so impatient to get away and felt a little down at the delay at staying there. It was Sunday morning, I went for a walk. While strolling across the farm of Mr. William Oosthuizen on the Western boundary of the farm on which the house was being built, I made the discovery. I stumbled over an outcrop of rock and on examining it found it to be conglomerate. I became the prospector, chipping a bit here, a bit there off the rock . . . ."

He continues, after saying that he panned the rock and found it to be rich in gold:

"After finding it, all idea of going to Barberton was knocked in, and I kept the find a secret, even from my chum Harrison for the time being. But while I was away in search of money, my secret became public property. A carpenter, named George Honeyball, was responsible for it. He has also been working at the Confidence Mine. After coming over to visit the widow Mrs. Oosthuizen he found the place where I had opened out a little and took some of the reef to the Confidence Mine and showed it to Mr. Godfray Lys, who with the Strubens was interested in the Confidence Mine. It was only a matter of a few days then before the important nature of the find became public."

Honeyball, in his statement to J. L. P. Erasmus, dated 28th November, 1935, denies that Walker helped in the building of the house. He says, "Walker had nothing to do with the building of the house, as alleged by Ackerman; he (Walker) being merely on a visit to his friend Harrison").

Walker's Version of the Discovery made to and signed before J. L. P. Erasmus on the 13th July, 1924.

On the 13th July, 1924, Walker gave another account, which was edited by J. L. P. Erasmus.

It will be remembered that in his statement to F. J. du Toit, Walker said "In 1886 came back to Free State to rest a while. Started once again making my way for the diggings at Barberton. On the road met old friend by name George Harrison". In this statement of the 13th July, 1924, he says:

". . . returned to the Free State (Kroonstad)—after resting here a few weeks met my mate George Harrison, a mason, I went back to Barberton. We got as far as Mulder's Drift, where we heard that the Strubens wanted a miner. I joined the Strubens at the Confidence Mine. Here I worked for some four months, after which I left and came

on to Langlaagte, where my mate Harrison was building a house for Hendrik Oosthuizen. . . .

"One Sunday morning, in February, 1886, I was taking a walk round the locality near the said house when I stumbled over the Main Reef which was obscured by grass rank and high. I broke off a piece of reef, brought it to the house where I panned it and found ring of gold round the pan. I immediately recognised that the reef was rich. The stone seemed peculiar to me. I did not know what to think of it, as I did not know Banket Quartz. It was my habit to pan any peculiar stone I did not know. I did not show my panning to Harrison or anybody else that Sunday morning."

He continues his statement by saying that he got a three months' free prospecting contract from Willem Oosthuizen, owner of the farm, and a 12 months' option to renew the contract on payment of £60. He says:

I did not tell him (Willem Oosthuizen) that I had struck the Main Reef. I then asked him for the loan of a horse as I wanted to go to Pretoria where I wished to report to the Government that the farm was gold-bearing as I told him. After the expiration of the three months I had to give up my contract with Oosthuizen as I could not find the required £60 to pay for the 12 months' prospecting rights aforementioned. All I ever got from Willem Oosthuizen for my discovery and trouble were two claims on Langlaagte exactly where I made my first discovery. One of those claims I subsequently sold to one van Rensburg for £350 cash and the other claim I gave to my mate Harrison."[1]

Comparison and Analysis of Walker's Two Accounts.

A comparison and analysis of these two statements by George Walker discloses the following important facts, which are relevant to a consideration of the credence one should attach to his story, apart from the conflicting versions of his story given, either by himself or by some unknown person to (*a*) Fred Struben, (*b*) George Honeyball, (*c*) W. H. A. Pritchard, (*d*) Willem Oosthuizen, Junior, and to canteen votaries while he was cadging for drinks, according to Pritchard's evidence.

These are the facts which emerge:

Firstly: The Main Reef was discovered on Portion C of Langlaagte. The owner hereof was G. S. Oosthuizen and *not* Willem Oosthuizen, who was one of his sons. Documentary evidence shows that Jan represented his father during his absence (*vide* Plates 31 and 32).

Secondly: Walker must have known this, because on the 12th April, 1886, he and Harrison signed a free prospecting contract for an unlimited period, with G. C. Oosthuizen, the owner (*vide* Plate 30).

Furthermore, on the 2nd September, 1886, he solemnly declared before the Notary C. Ueckerman, at Langlaagte, that the "prospector's claim" he was selling to van Rensburg was obtained by him from G. C. Oosthuizen in terms of his contract of the 12th April, 1886. It could, therefore, not have been a gift from Willem Oosthuizen or from his father.

This was the only claim Walker ever had, and, on the 4th October, 1886, he took out a "Licentie tot onderzoek" in order to comply with the terms of Article 54 of the Gold Law, otherwise he would not have been entitled to the "Delvers" licence for this claim after proclamation, and which he had already sold to van Rensburg, on the 2nd September, 1886 (*vide* Plates 75, 81, 82, 83).

Thirdly: According to his own admission, Walker returned to the Free State at the beginning of 1886—remained there for a few weeks—then proceeded to return to Barberton—met Harrison at Mulder's Drift—engaged himself as a miner to the Strubens, worked for them for four months and thereafter went to join Harrison at Langlaagte. Accepting these facts, then Walker could not have made his alleged discovery on the 7th February, 1886, on Langlaagte, and could not have arrived on Langlaagte earlier than April, when he and Harrison obtained the free prospecting contract from G. C. Oosthuizen (*vide* Plate 44).

Fourthly: Walker could not, prior to this, have had a free prospecting contract from Willem Oosthuizen for a period of three months, and have lost that contract after the expiration of that time, because he could not find the £60 for the 12 months extension, because the contract of the 12th April, 1886, which he and Harrison obtained from G. C. Oosthuizen, was for an unlimited period and was also free. Walker's statement: "I had to give up my contract with Oosthuizen as I could not find the required £60 to pay for the 12 months' prospecting rights aforementioned", is and must clearly be a pure invention, and is undoubtedly false. The Committee also rejected this story.

Fifthly: Walker at no time, prior to the 4th October, 1886, took out a "licentie tot onderzoek" in terms of Article 9 of the Gold Law, which would have entitled him as a reward for any discovery of payable gold, to one claim, named and registered as a "*Zoekersclaim*" and which would also have given him the right to have the payability investigated by the Government and to request the proclamation of the farm as a public digging (*vide* Plate 81).

Sixthly: Walker, at no time, reported to the owner or to the Government (he says in his statement to Erasmus of the 13th July, 1886, that he wanted to borrow a horse from Willem Oosthuizen to go to Pretoria to report to the Government) that he had discovered Gold (not payable gold) on Langlaagte.

Having regard to the conflicting stories of his alleged discovery told by George Walker himself (this fact is admitted by the Committee of Enquiry), and taking into consideration the irreconcilable versions of the said discovery testified to by the persons mentioned in the preceding paragraph, anyone of common sense is entitled to take a serious view of the class of evidence accepted by the Committee and of the weight given to such evidence, in arriving at its finding "that George Walker, probably in association with George Harrison, was the Discoverer of the Main Reef".

As mentioned, the "statement" of Struben's was, of course, no evidence at all. Prof. Leo Fouché writes "that the (tested) hearsay evidence in this case is overwhelmingly in favour of a Joint Discovery by the two Georges". What the tests were which were applied is nowhere disclosed, and this assertion now of a "joint discovery" is a remarkable feat of confused mental agility.

Other Accounts given by Walker of his Discovery.

There are two other newspaper accounts given by Walker of his alleged discovery, the one appeared in the "Sunday Times" of the 7th April, 1924, and the other in the "Rand Daily Mail" of the 24th February, 1924. In this latter account he says:

> "While there doing so, I strolled about one Sunday morning in February, 1886, fell over and knocked off a bit of the outcrop of the Reef, panned and found it very rich in gold, and told the owner of the farm, Willem Oosthuizen, about it. On the Monday I got a three months' gratis prospecting contract from him, with the right to prospect for another year for £60 and right to purchase the farm. During the three months I started opening up the Reef, and, at that time, one George Honeyball, turned up at the farm, the portion belonging to Mrs. Widow Oosthuizen, and lived with them. He was the man who took up the Conglomerate to Messrs. Struben and Lys without my knowledge, as I was keeping my discovery a secret until I could find some money for the option."

A comparison of this account with the other two, will disclose the irreconcilable contradictions.

Presumed Corroboration of (tested) Hearsay Evidence.

One can only presume that "the (tested) hearsay evidence", referred to by Professor Fouché, is what is set out in the rest of the paragraph on page 36 of the Report, which reads as follows, viz.:

> "This statement of Fred Struben was fully and emphatically confirmed in the evidence given to the Committee by witnesses who were on the Rand at the time of the discovery, such as Honeyball, and more especially H. J. Liebenberg, or who came shortly after, such as W. H. Auret

Pritchard. These witnesses spoke both from their personal knowledge and that of their contemporaries. All this body of evidence is further corroborated by the statements of Willem Oosthuizen and others. In view of this, the Committee is of opinion that Walker should have first place as the Discoverer of the Main Reef on the Witwatersrand Goldfields."

An analysis of this paragraph clearly reveals the fact that the Committee considered that the witness Honeyball, and more especially H. J. Liebenberg, fully and emphatically confirmed the statement attributed to Struben by Mathers, and that one finds further corroboration of that statement in the evidence of W. H. Auret Pritchard, Willem Oosthuizen and others. An examination of the stories of these witnesses, therefore, becomes necessary.

Honeyball's Story.

The Committee found that George Honeyball had "added many picturesque details" to his story in recent years (see page 19 of the Report). The story told by Honeyball supports the story of Walker in one respect only, and that is, that "Walker said he had discovered the Main Reef on Sunday, the 7th February, 1886". He says that Walker showed him and Harrison on Sunday evening, the 7th February, 1886, in Malan's or Vivier's canteen, after they had "refreshed the inner man and become happy" (according to J. L. P. Erasmus) the rock that he had found, and that the next day Walker took him actually to the very spot where he had made his discovery and so on.

This story is most emphatically denied by Walker in *all* his versions of the discovery. The repetition of a story to others is not confirmation or proof of the truth of that story. The statements made by Honeyball at other times are so unreliable and so contrary to facts that have been undisputedly established, that it would be a waste of time to make any further analysis of his evidence. The Committee unreservedly rejected both the evidence of Walker and of Honeyball as to the date of the alleged discovery, namely, Sunday, the 7th February, 1886.

H. J. Liebenberg's Evidence.

Coming now to the assertion of the Committee that the evidence of H. J. Liebenberg "fully and emphatically and more especially confirmed Struben's statement", the most generous comment that one could make is that the members were either dreaming or having delusions, when they committed themselves to such a conclusion.

H. J. Liebenberg's evidence has *nothing whatever* to do with the alleged discovery of the Main Reef on Portion C. of Langlaagte, belonging to G. C. Oosthuizen, on the 7th February, but

refers to an incident, witnessed by him in the winter of 1886, in June, on Portion D. of Langlaagte, belonging to the widow Petronella Oosthuizen.

H. J. Liebenberg was owner of Portion of Turffontein, also later on proclaimed. He gave evidence before the Committee on the 22nd February, 1939. He says he was on a visit to Louis Oosthuizen, early in June, 1886, and found Walker, Harrison and Louis Oosthuizen sitting on a ridge (rand), each with a stone in his hand, and that Walker said the stones contained Gold, that they crushed the stones and found that they did contain gold.

He says, that, at the time, they were breaking stones for the building of Hendrik on the widow Petronella Oosthuizen's Portion D. of Langlaagte.

He continues: "The story of Walker and the stumbling over the stone is incorrect. . . . Honeyball was of minor importance, he always remained on one side. He stayed with the Oosthuizens. He was a hanger-on ('n los kerel)."

On the 23rd April, and again on the 25th May, 1946, I interviewed H. J. Liebenberg. He confirmed the evidence he had given before the Committee, and was especially emphatic that it was in the winter, in June, 1886, that the incident mentioned by him took place on the Widow Petronella's portion of the farm. He again denied the story of Walker, that he had stumbled over an outcrop and so discovered the reef. He further said that there was no truth in Honeyball's claim that he had found the Main Reef Leader in the Widow Petronella's mealie lands. He said a farmer does not plough where there are stones.

Geologically, it has been proved that the Main Reef and the Main Reef Leader are so closely connected on Langlaagte, that they are indistinguishable, so how Honeyball could have discovered the Main Reef Leader in the mealie lands is a mystery.

Evidence of W. H. A. Pritchard.

The next witness whose evidence is said to "corroborate and confirm" Struben's statement is that of W. H. A. Pritchard, who arrived on the Rand on the 22nd August, 1886. Mr. Pritchard gave evidence before the Committee on the 28th February, 1939 (that is 53 years after his arrival), and he was expected from memory to relate what had happened in the dim past. What reliance can one place on such evidence, especially where it is unsupported by any contemporary or other documentary writings? *He has admitted that his sole source of information was George Walker.*

The evidence of Mr. Pritchard does not corroborate Struben's statement. All it does is to disclose the fact that Walker also told him his story after his arrival. Furthermore, the facts remembered by him are flatly contradicted by the official records

and other documentary evidence unearthed by Ethel L. Gray. He says, *inter alia*, this:

> "I heard Walker tell the story of his discovery of gold over and over again. I never had a conversation with Harrison. I took no notice of Harrison. Walker was always talking. In all the conversations at the canteen in those days Walker was spoken of as the discoverer. Walker got many a free drink on the strength of being the Discoverer. Honeyball was never mentioned. I did not know there was such a person until quite recently."

This is the relevant portion of Pritchard's evidence which the Committee had the temerity to say corroborated Struben's statement and proved, as a fact, that Walker was the discoverer. The mere disclosure of these facts should suffice to establish the hollowness and futility of such a contention.

Mr. Pritchard in his letter to me of the 17th September, 1946 (see Appendix 3), reaffirms the above evidence. He does, however, add one bit of evidence which is at variance with Walker's story. He said "Walker told me he had secured an option from Oosthuizen to prospect that portion of Langlaagte for two years at £30 per annum"; also, that he had walked to Potchefstroom and Pretoria to get someone to put up that amount—but no one would listen to him.".

In the "Rand Daily Mail" of the 5th December, 1935, Mr. Pritchard wrote that "Willem Oosthuizen was the owner of the farm which Walker obtained the option to prospect".

It has been established beyond doubt that G. C. Oosthuizen was the owner. The Committee also, as a fact, rejected Walker's story about having obtained a three months' free option from Willem Oosthuizen.

The persistent way in which Walker mentions Willem Oosthuizen as the owner and the deliberate suppression of the fact, that he and Harrison had obtained a free prospecting contract on the 12th April, 1886, from G. C. Oosthuizen and that he had received only one "prospector's claim" from G. C. Oosthuizen in terms of that contract, leads one to the irresistible conclusion that Walker was a champion bluffer and prevaricator. In his statement to Erasmus he said he obtained two claims from Willem Oosthuizen one of which he gave to Harrison. He must have known that his mate Harrison had reported his discovery to G. C. Oosthuizen, the owner—that Harrison had gone with Oosthuizen to Pretoria and had received as a reward a "*Zoekersclaim*" for his discovery. In fact, as will appear later on, on the 26th July, 1886, he actually signed a petition in which he testified, that Harrison was the "prospector" of G. C. Oosthuizen's farm and that he (Harrison) had discovered payable gold.

It is also remarkable, that Harrison does not in any of his official statements or reports mention Walker as having been "associated" with him in the Discovery (*vide* Plates 34 and 35). Walker is said to have been no fool; he was fully acquainted with the Gold Law and with the rights of a Digger thereunder, and it is, therefore, not likely that he would have allowed Harrison to get away with the benefits of any discovery he (Walker) had made. In fact his loyalty to his "pal" was not a feature of his character—because he admits that he didn't even tell his mate of his alleged Discovery, but kept it a dead secret until that Carpenter (?) Honeyball, gave the show away.

It is interesting to note what Hedley Chilvers, who knew Walker, says about him in "Out of the Crucible". He says:

> "But Walker was a garrulous character and could not keep a secret. He had been known to walk fifteen miles to spend his wages and gather gossip of the byways."

EVIDENCE OF WILLEM OOSTHUIZEN, JR., AND OTHERS.

The evidence of Willem Oosthuizen, Jr., and others is too vague to consider seriously. One does not know what Willem (who was a lad of 19 years of age at the time and a grandson of G. C. Oosthuizen) could remember of what happened on Langlaagte in 1886. He was found by J. L. P. Erasmus, to whom he made a statement which was published in "The Star" of the 17th April, 1936—just 50 years after the alleged discovery. An examination of this statement shows that it is either pure hearsay (what he was told by others long since deceased), or is in conflict with established contemporary documentary evidence.

This concludes the "hearsay evidence" which the Committee accepted and relied upon to arrive at its conclusion set out in finding (8) in support of George Walker's claim to be declared the Discoverer of the Main Reef.

There is not a tittle of documentary evidence in support of Walker's claim. The Committee, in fact, deliberately disregarded, rejected and belittled the value and the weight of the official records and the other contemporary documentary evidence, and even the decisions of two courts of competent jurisdiction, in support of George Harrison's claim to being the Discoverer.

This documentary evidence will now be reviewed so as to enable the unbiassed reader to decide for himself the only issue in this controversy, namely: "Hearsay evidence and its value on the one side, and Official Records and other documentary evidence and their value on the other side."

George Walker's mining activities are not included in the terms of the Definition of "Discovery" and "Discoverer" accepted by the Committee.

Before passing in Review and considering the official records and other documentary evidence, in support of George Harrison's

claim and wrongly rejected, it is necessary to draw the attention of the reader to the definition of the words "Discovery" and "Discoverer" accepted by the Committee, and according to which no one would be entitled to be declared the "Discoverer" unless his activities were covered by the terms of that definition.

The Committee says: "Discovery means and should be taken to mean, not merely the act of finding and exposing to view such reefs, but also the disclosure or publication of such finds, and the consequent opening up of such reefs, leading eventually to actual exploitation." The Committee also accepted the following statement made by Mr. Sturrock, the Minister, namely: "I take it that your object is to decide who was the first man to prove and open up the Main Reef, and not those who claim to have picked up an odd bit of rock here and there."

Now, the reader is invited to consider and weigh the evidence, relevant to this issue, given by W. H. A. Pritchard and accepted by the Committee, and pronounced by it to "fully and emphatically" confirm the statement of Fred Struben. This is what Mr. Pritchard told the Committee in his evidence on the 28th February, 1939:

> "Question by F.: Had he (Walker) done much work?
>
> "Reply (by Pritchard): No, he had done nothing, that was prior to the Proclamation. Walker, I am quite prepared to say, did not put a spade in the ground.
>
> "Question by F.: Was that not curious?
>
> "Reply by Pritchard: An outcrop was standing a few feet high and all he had to do was to break a piece off it. . . . Walker himself did not do any work. All he wanted to do was to sell. . . . Walker was always talking. . . ."

I would not insult the intelligence of the ordinary reader by pointing out the utter impossibility of even attempting to reconcile this evidence with the accepted terms of the Definition.

This evidence alone should have disqualified George Walker's alleged find (if he ever did make a find), to be a "discovery", and did not justify the Committee in declaring him to be the "Discoverer".

Relevant Provisions of the Gold Law Wet No. 8 1885.

With a view to enabling the reader to understand and appreciate the importance and evidential value of the public records and other documents establishing George Harrison's claim, it is necessary first to examine the relevant provisions of the Gold Law.

Article 8 provides that anyone who wishes to prospect for gold on private property must obtain the permission of the owner to do so, and take out a "licentie tot onderzoek", costing 10/- per month, half of which accrues to the owner.

Article 9 is important. It provides that the Discoverer of payable gold on private or government property, shall, when proclamation of such land is decided upon, be entitled to receive and to peg off one claim (reef or alluvial) which shall be named and registered a "*Zoekersclaim*". In addition, the Discoverer shall be entitled to work this claim without payment of any licence fees, as long as he remains owner thereof.

Article 10 provides that if the conditions set out in Articles 8 and 9 have been complied with, then the President may proclaim such ground a public digging.

Article 11. The Discoverer (zoeker) who flinds payable gold, having complied with Articles 8 and 9, shall not lose his right to a "*Zoekersclaim*" should the Government or owner be unwilling to proclaim the ground.

Article 12 indicates the steps the government must take to prove the "payability" of the discovery.

Article 13. The holder of a "licentie tot onderzoek" shall, immediately after his report of his discovery has been made, and the payability of his find been proved, be entitled to all the rights of an ordinary digger, and those rights he shall retain even if the owner refuses to have the ground proclaimed.

Article 14. Only after the Discoverer has secured his rights above-mentioned shall the owner of the ground be entitled to peg off 10 claims ("eigenaars" claims) and work them by paying the ordinary licence fees. In Article 19 these are called "voorkeurclaims". Only thereafter shall other diggers be entitled to peg off claims according to Law.

Article 16. The registration of a "*Zoekersclaim*" shall be done by the Mining Commissioner or Landdrost of the district.

Article 31. The Mining Commissioner shall keep a register of: (*b*) All "licentien" issued to diggers to exercise the right to dig: (*c*) a register of all "licentien tot onderzoek": (*d*) All "Delverslicentien" issued on ground belonging to concessionaries.

Article 54. When ground has, in terms of the Law, been proclaimed, then all persons who have under a "licentie tot onderzoek" pegged off Zoekers-claims (viz. claims acquired while prospecting or while seeking for gold), shall be entitled to retain those claims, provided they have complied with the Law. In the marginal note these claims are also referred to as "Prospecteer-claims".

Article 56. Provides that a digger's claim may not be jumped, unless the Digger has ceased to work his claim for 14 days.

Article 61. To be entitled, after proclamation, to dig for gold, every white person shall have the right to obtain a "Delverslicentie" by payment of £1 per month.

Article 28. Provides that the Mining Commissioner shall have the right to decide all disputes affecting the Diggings, and

shall have the same jurisdiction as a Special Landdrost in all civil and criminal matters. An appeal from his decisions in these matters shall lie to the High Court.

Articles 41 and 42 provide that there shall be an appeal from the Mining Commissioner's decisions in all matters affecting diggers' disputes or having reference to mining, to the "Delvers Comitee" and thereafter an appeal lay to the High Court.

Legal distinctions between the Discoverers's "Zoekersclaims" (one word, in italics, in the Law) mentioned in Article 9 and to be pegged off "when" the Proclamation had been decided on, and "Zoekers-claims" (two words, ordinary type) of other prospectors for or seekers (zoekers) after gold to be pegged "after" proclamation, mentioned in Article 54.

By comparing Article 54 with Article 9 the following differences stare one in the face:

(*a*) In Article 9, the claim named and registered as a "*Zoekersclaim*" (one word and printed in italics in the Law), can be pegged off only by the discoverer, in Article 54 the claims mentioned can only be pegged off after the proclamation has been decided upon. These claims are referred to as "Zoekers-claims" (two words, in ordinary type) and can only refer to the claims, not of the discoverer, but of such other persons as had been prospecting the ground, with permission of the owner, after having obtained a "licentie tot onderzoek". In the marginal note these claims are also called "prospecteer-claims".

(*b*) In Article 9 again the Discoverer is not entitled to his "*Zoekersclaim*" unless and until the payability of his discovery has been established, whereas in Article 54 the question of payability does not and cannot arise, because the government had already ascertained the payability and had decided to proclaim the ground.

(*c*) The persons mentioned in Article 54 can only retain their claims, provided they complied with the Law; this means, that if they desired to work their claims, they must take out a "Delverslicentie" in terms of Article 61, and pay £1 a month therefor, whereas the Discoverer, in terms of Article 9, can work his claim without payment of any licence, as long as he remains owner thereof. These differences are self-evident and, yet, the Committee failed to understand and appreciate them, and indulged in a long legal argument (which a first-year student would have blushed to adopt) to show that the Grays were wrong in basing their conclusions on the meaning of the word "*Zoekersclaim*" mentioned in Article 9. The Grays, as a fact, did nothing of the kind. This was a misstatement of fact.

The marginal note to Article 54 reads " Beaconed off prospecteer-claims " retain their rights in the event of a Proclamation as a Public Digging.

Review and analysis of the official records and other contemporary writings, conclusively establishing George Harrison's claim to be declared the Discoverer of the Main Reef, and wrongly disregarded and rejected as valueless by the Committee.

George Harrison's right to be declared the discoverer is based entirely upon official records and other contemporary documents. One is not asked to rely upon " hearsay ", " gossip ", " canteen conversations " or other such stories. Records kept in accordance with statutory provisions, are conclusive evidence of the facts stated therein, unless it can be proved, that mistakes have been inadvertently made or a fraud has been practised by or on the official called upon to keep the records.

No question, therefore, can arise as to the authenticity and reliability of this documentary evidence. The vagaries of the human memory in recalling incidents years after they have taken place, are thereby eliminated.

Sequence of events leading up to the Proclamation of Langlaagte and other farms as a public gold digging.

In March and April, 1886, the activities of the goldseekers in the Langlaagte area became intense and there can be no doubt but that gold-bearing rocks had been discovered but that the *payability* of the finds had not been established which would have entitled the owners to ask the Government to proclaim their farms in terms of the Gold Law.

On the 12th April 1886, G. C. Oosthuizen granted, on his portion C. of Langlaagte, a free prospecting contract for an unlimited period to George Harrison and George Walker, containing the stipulation, that *when* they should find *payable* gold, they would receive, as a reward, each, one claim, a stand and water rights. This was not an exclusive right to them, and Harrison and Walker signed this contract, not as partners, but as co-prospectors.

On the 21st May, 1886, George Harrison in terms of the Gold Law took out a " licentie tot onderzoek " for the period 23rd May till 23rd June, 1886, to prospect G. C. Oosthuizen's portion of Langlaagte. This licence he renewed from time to time, and, on the 24th September, 1886, Captain van Brandis himself, the Mining Commissioner, renewed this licence until the 24th October, 1886 (*vide* Plate 41). J. Eloff, the Civil Commissioner of Pretoria on the 28th June, 1886, reported to the State Secretary, that Harrison did not know whether the farm fell within the Heidelberg or Potchefstroom districts, and that he took his licence out in Pretoria, because " he could not wait with his

work". This shows that Harrison was actively engaged in prospecting and mining (*vide* Plate 40).

Eloff also reported that George Walker had not taken out any "licentie tot onderzoek". Harrison paid 10/- for his licence, and, on the 8th June, 1886, G. C. Oosthuizen personally collected his half share, namely 5/-, in Pretoria.

On the 9th June, 1886, G. C. Oosthuizen writes to the Government that he had been informed that payable gold had been found on his farm, asks that the report be investigated and, if found to be correct, then to proclaim his farm as a public digging. This letter G. Oosthuizen and George Harrison personally handed to the Government at Pretoria.

On the 7th July, 1886, a petition was presented to the Government stating that the petitioners had been informed "from the best sources" that payable gold had been found on Turffontein and Langlaagte and requesting the Government to proclaim these farms. (It should be mentioned that I. P. Ferreira was one of the petitioners. (See page 88—Gray's "Payable Gold".)).

On the 23rd July, 1886, G. C. Oosthuizen writes a personal letter to President Kruger from his bushveld farm, Klipplaats, saying that Gors Harrison had told him that he had discovered payable reef on his farm and ends with "so I send him to you, then Mr. Kruger, you can talk to him yourself".

On the 24th July, 1886 (the day after), George Harrison, after having delivered this letter to the President at Pretoria, made a statement in the State Secretary's office as follows:

> "My name is George Harrison and I come from the newly discovered goldfields, Kliprivier, especially from a farm owned by Gert Oosthuizen. I have a long experience as an Australian gold-digger and I think it is a payable goldfield." ("Payable Gold," facing p. 96.)

On the 26th July, 1886, a petition was signed by I. P. Ferreira and 73 others and sent to the Government, stating as follows: "That they have been informed and are convinced that gold in payable amount has been found on the portion of the farm Langlaagte, situate in the district of Heidelberg, Ward Kliprivier, the property of G. Oosthuizen. That they are assured of this as a fact both from personal experience and by the prospector of the said farm, named Harrison, who has prospected there with the consent of the owner." They consequently request the Government to proclaim the farm as a public digging.

It should be noted that this was the second petition presented to the Government relating to Langlaagte. *This petition was signed by George Walker* (*vide* Plates 34 and 35).

The official records show that the Government, acting on the representations made, immediately set the administrative machinery in motion to comply with the provisions of the Gold Law. The steps taken, supported by official records, were the following (*vide* Plate 38):

(*a*) The Surveyor-General was instructed to prepare the plans of the farms in question.

(*b*) The payability of the discoveries were examined and a report thereon made to the Government.

(*c*) A Commission, consisting of C. J. Joubert and Johann Rissik, was appointed on the 3rd August, 1886, to report on the farms to be included in the Proclamation.

(*d*) The question of the issue of "Licenties tot onderzoek" was investigated, as no person could receive, as a reward for his discovery, the "*Zoekersclaim*" referred to in Article 9, unless he had been in possession of such a licence. The report of J. Eloff (already referred to), is dated 28th June, 1886 (*vide* Plate 40).

On the 18th August, 1886, the President signed a notice to be published in the *Gazette*, informing the public that, on investigation, payable gold reefs had been discovered on certain farms mentioned (including Langlaagte) and calling upon the owners and other representatives to secure their rights under the Gold Law within one month, as the Government proposed to proclaim the farms as a public diggings.

On the 8th September, 1886, the President proclaimed the Witwatersrand Goldfields a public Digging in terms of Article 5 of the Gold Law (No. 8 of 1885).

On October the 4th, 1886, the farms Randjeslaagte (on which Johannesburg was laid out) and Langlaagte were thrown open to the public as a public digging. George Harrison, the licensed prospector, in terms of Article 9 of the Gold Law received a claim, No. 19, named and registered as a "*Zoekers-claim*" as a reward for his discovery of payable gold on portion C. of Langlaagte, belonging to G. C. Oosthuizen. Harrison was also entitled to peg off a prospector's or zoekers-claim in terms of Articles 54 and 61 of the Gold Law, and in terms of his contract of the 12th April, 1886. He obtained a "Delvers-licentie" for this claim on the 5th October, 1886, and paid £1 licence fee. George Walker received, in terms of his contract with G. C. Oosthuizen, of the 12th April, 1886 (and not as a gift) a prospector's claim, No. 21, which was converted, after proclamation, into a "Delvers-claim", in terms of Article 54 of the Gold Law, after he had taken out a "Licentie tot onderzoek" on the 4th October, 1886, to cover his right (the very day of the proclamation). This claim or his right thereto Walker had already sold to van Rensburg on the 2nd September, 1886, for £350. He had no other claim.

George Harrison sold his "*Zoekersclaim*" on the 11th November, 1886, to Frank W. Marsden. Marsden again sold the same claim to Alfred Heppell for £50 on the 3rd March, 1887.

On the 25th September, 1886, the Paarl Syndicate, which had acquired all G. C. Oosthuizen's rights on the 4th August, 1886, took exception to George Harrison having pegged off two claims and George Walker one claim, and stated that, as G. C. Oosthuizen had only agreed to grant two claims in terms of the contract of the 12th April, 1886, an explanation was demanded.

On the 12th October, 1886, George Harrison, submitted a declaration, to the Mining Commissioner, C. von Brandis, explaining the whole position. In this declaration he categorically says: "that I am the original prospector of one-quarter of the farm "Langlaagte", belonging to Gert Oosthuizen, and *when I discovered reef on the said place, which was payable, me and the owner of the said place went to Pretoria and exhibited the quartz to his Honour, the President, and there declared it was payable*", and so on. He ends thus: "I therefore humbly request, that a proper investigation shall be made of these matters, and I sincerely trust that Your Worship will appoint an early date as my *work* is going on daily and I am bound, in my own interest to see to the same and to watch proceedings on the spot" (*vide* Plates 45, 46).

Captain von Brandis, as Mining Commissioner, must have investigated the complaint, because nothing further is recorded about the complaints, and George Harrison retained his two claims one—No. 19—his "*Zoekersclaim*" and the other his "Delversclaim" (*vide* Plate 42).

It is a significant fact, as already mentioned, that George Harrison, at no time, in all his reports and declarations, makes any mention of George Walker as being associated with him in the actual discovery. From this circumstance, and other evidence collected, it is reasonable to infer that Walker must have received his claim from G. C. Oosthuizen through the representations of Harrison, because they had jointly signed the contract of the 12th April, 1886. This also bears out and supports Pritchard's evidence, that Walker did no work, didn't put a spade in the ground, was always talking and only wanted to sell. It is a further significant fact, and requires a great deal of explanation, that George Walker, in all his stories, deliberately omits to make any reference at all to the contract of the 12th April, 1886. The reason seems to be obvious—because, if he had done so, his fairy tales would have been exposed, especially that he had given one claim to Harrison as a gift and that he had obtained two claims from Willem Oosthuizen for his discovery and for all his trouble. Erasmus commiserates with the poor man in having had this bad luck! There was, of course, not a word of truth in this.

Decisions in the case of Bezuidenhout vs. Marsden and Heppell.

This concludes the evidence reflected in the official Records and other contemporary writings. But there is still further proof of an *unimpeachable* nature, conclusively establishing the fact, that George Harrison was the discoverer and received as a reward, in terms of Article 9 of the Gold Law, a claim, named and registered, "*Zoekersclaim*", for his discovery.

On the 9th July, 1887, H. Bezuidenhout, a digger, notified the Mining Commissioner, that he had "jumped", in terms of Article 56 of the Gold Law, claim No. 19, Harrison's "*Zoekersclaim*" which had been sold to Marsden and Heppell, and contended that he was entitled to do so in terms of Article 56, because the claim had not been worked for 14 days.

The dispute came before Captain von Brandis, in his capacity as Special Landdrost. It will be remembered, that in October, 1886, Captain von Brandis, as Mining Commissioner, had investigated the Paarl Syndicate's protest to Harrison being entitled to two claims. Mr. du Toit, Attorney for the Plaintiff, admitted that the claim was the "*Zoekersclaim*" granted to the discoverer as a reward in terms of Article 9, but the contention was, that because Harrison had sold his claim, his successors in title, as they had to pay licence fees, did not enjoy the same protection as the discoverer, and, therefore, the claim could now be jumped, as it had lost its privileges and fell under Article 56.

Advocate Jeppe appeared for the Defendant. He had also been a gold-seeker in June, 1886, and was consequently fully acquainted with the events of that period. It goes without saying that Captain von Brandis was also fully aware of how Langlaagte came to be proclaimed by him, as Mining Commissioner. No mistakes could, therefore, have been made regarding the *facts*. The only question, therefore, which had to be decided, was one of *Law*—namely, whether Mr. du Toit's contention was correct. The Court decided "that a claim of a discoverer of payable gold, acquired in terms of Article 9 of the Gold Law, is not governed by Article 56, and the Court finds the 3rd exception well-founded and dismissed the claim with costs; that the claim of such a prospector worked or not worked, cannot be jumped".

In terms of Article 41 of the Gold Law there lay an appeal to the Diggers' Committee. On the 11th August, 1887, this Committee unanimously upheld the above decision. It would be preposterous even to suggest that the members of the Diggers' Committee could have been ignorant of the true facts or could in any way have been misled or deceived (*vide* Plates 58, 58a, 59, 60, 61, 62, 63, 64 and 65).

This concludes my "Concise Summary of the Evidence". Only the most important facts could be and have been stated.

Sufficient, however, to enable the reader to decide the issues for himself.

Conclusions.

Walker's Claim.

George Walker's claim to be declared the "Discoverer" cannot be supported, to mention only two reasons: *Firstly*: According to the evidence of Wm. H. Auret Pritchard, Walker did no work and did not even put a spade in the ground. He is alleged to have stumbled over an outcrop, broken off a bit, panned it and found it to be gold-bearing—and nothing more. This evidence having been accepted by the Committee, it is logically impossible to bring his activities or rather inactivities within the meaning of the Definition of "Discovery" and "Discoverer", given to those words, by the Committee itself. *Secondly*: Walker's claim is based on "Hearsay evidence and canteen gossip" which is of no value. There is not a tittle of documentary evidence in support of it, and it is at variance with all the facts, incontestably established by the official records and other contemporary writings.

We have only Walker's statement that the outcrop, which he said he had stumbled over, contained any gold, as Honeyball's story (p. 18) was emphatically denied by Walker, and Godfray Lys's account ("Rand Daily Mail," 22/9/1906) was contradicted by Lys himself in a declaration to J. L. P. Erasmus (10/10/1935)—in fact the Committee admits that Walker made no assays or had any milling done.

George Harrison's Claim.

George Harrison's claim again is based on and supported by the Records, officially kept in terms of the Law, by contemporary documentary evidence and by the decision of two Courts of competent jurisdiction, when it was decided, as a *fact* that Claim No. 19 was the "*Zoekersclaim*" which had been granted to him as a reward for his Discovery in terms of Article 9, of the Gold Law, and that, *in Law*, that claim, worked or not worked, could not be "jumped", even although the "Discoverer" had parted with his rights to others. And lastly, on the 26th July, 1886, George Walker himself, Harrison's mate, signed a petition, with others, requesting the Government to proclaim the farm Langlaagte as a public digging, because they were convinced both from personal investigations and from information obtained from the prospector of the said farm, named Harrison, who had been prospecting the farm with the consent of the owner, G. Oosthuizen, that gold, in payable quantities, had been found.

Appendix No. 1.

Invitation to Committee.

After the publication of the undisputed facts in this paper, one must not be surprised that in future the confidence of the

public in the judgment and decisions of some of the members of the Monuments' Commission cannot and will not be accepted uncritically. Whoever accepts "Hearsay Evidence" and "canteen gossip", and rejects official records and other contemporary writings, as the foundation for his decision, must arrive at novel and fantastic conclusions.

The Committee is now invited to state on what grounds it felt justified in rejecting all this documentary evidence in favour of Harrison's Claim, and to disclose the names of the witnesses and the nature of the evidence, on which it decided that George Walker, either alone or in association with Harrison or jointly with Harrison, was a discoverer.

Should these members accept my invitation, it might be advisable for their guidance and for the information of the public to state concisely what the position is, so that there can be no misunderstanding as to what really my invitation involves.

Firstly: The Committee rejected and therefore disbelieved, both Walker's and Honeyball's stories as to the alleged date of the discovery, namely, Sunday, 7th February, 1886. (There is ample evidence in support hereof.)

Secondly: The Committee rejected and disbelieved Walker's story when he said, or told others, that he had obtained a free option for three months from Willem Oosthuizen to prospect and thereafter the right to a year's option at £60, with the option to purchase the farm. Willem Oosthuizen was not, but G. C. Oosthuizen was the owner of the farm. There is ample evidence to prove that Walker knew this, so why did he drag in the name of Willem Oosthuizen?

Thirdly: Walker persists in saying that he kept his alleged find a "secret" until that "Carpenter" Honeyball (Honeyball was a blacksmith) made it public, when there was an immediate rush of gold-seekers, including Robinson and others. As this could not have taken place earlier than the end of June or beginning of July, 1886, what explanation can be offered for Walker's choosing the 7th February as the date of his alleged find?

Honeyball again says that Walker told him and Harrison that very night—namely, Sunday the 7th February, 1886—after they had become "happy" in "Malan's" or "Vivier's" canteen of his find, and actually showed him, secretly, the spot of his alleged discovery the next day. Now which story did the Committee accept? It should be noted, that the acceptance of either the one or the other story entirely eliminates all association of Harrison in the discovery. So on what evidence has it been found that Harrison "jointly" or in association with Walker made the discovery? You can't have it both ways.

Fourthly: Walker, in all his stories, suppresses the fact that G. C. Oosthuizen, on the 12th April, 1886, gave him and Harrison

a free prospecting contract, and that the claim he had sold to van Rensburg, on the 2nd September, 1886, was obtained by him in terms of that contract, and not as a gift. This was the only claim Walker ever had. Can the Committee give or suggest any explanation why Walker should have suppressed all reference to this contract in his stories, and why he gave an untruthful account of his transaction, in conflict with his own solemn declaration to the Notary Ueckerman?

Harrison, on the other hand, candidly made mention of the contract between G. C. Oosthuizen and himself, but nowhere does he say that Walker was associated with him in the actual discovery. This is consistent with the fact that they were independent prospectors and not partners. In fact, nowhere does Walker speak of or say that Harrison was his partner. Walker, in the petition signed by him on the 26th July, 1886, speaks of Harrison as the "Prospector" of G. C. Oosthuizen's farm, Langlaagte. This supports Pritchard's evidence, that Walker did no work and never put a spade in the ground.

Fifthly: As the Committee discredited Walker's own version of his alleged discovery, one is entitled to ask on whose evidence did the Committee rely in coming to the conclusion that Walker did make the Discovery, either alone or jointly with Harrison? The nature of this evidence should be stated, and where it can be found, as I have not come across any such evidence. These simple and undisputed facts cannot be ignored. To shut one's mind to the light of knowledge is like choosing to be blind.

Sixthly: Prof. Fouché says that "the (tested) Hearsay Evidence in this case is overwhelmingly in favour of a 'joint discovery' of the two Georges". It would elucidate matters if the Committee were to state *what* these tests were and whether reliance was placed on such tests in addition to or apart from the "Hearsay Evidence" mentioned in arriving at its Findings.

And Lastly: The Committee is urgently invited to state on what grounds and for what reason—logical or legal—it disregarded and rejected the *facts* disclosed in the official records and other contemporary writings, incontestibly proving that George Harrison was the actual Discoverer of the Main Reef, that he reported his discovery to the owner and to the Government, requested the payability, in terms of the Gold Law, to be investigated, and on proclamation, as a reward for his discovery, received a claim, No. 19, named and registered in terms of Article 9 of the Gold Law as a "*Zoekersclaim*"?

Appendix No. 2.

Eminent Historians unreservedly Support George Harrison's Claim.

As the modern school of Historians which regards History as a Science and not as an Exercise in Literary Art is to-day

predominant, I submitted the evidence in Walker vs. Harrison to the following well-known Historians, viz.:

(1) The late Dr. Gustave Preller, who had also investigated the early history of Gold Discovery in the Transvaal and had written a book thereon.

(2) Dr. A. Kieser, the well-known Archivist of the Orange Free State.

(3) Dr. G. D. Scholtz, an outstanding writer on History.

(4) Dr. Coenraad Beyers, Chief Archivist of the Union.

They all agree that the official records and the other contemporary documents establish an unanswerable case in favour of George Harrison.

George Walker is entirely out of the picture. Except for "Hearsay Evidence" and "Canteen Gossip", there is no reliable evidence even to associate him with the actual discovery.

APPENDIX No. 3.

Enthusiastic Pioneers and George Walker.

I am advisedly dealing somewhat fully with the attitude of three old pioneers—enthusiastic, and even blind, partisans of Walker's claim—because it is necessary that the reader should, in weighing the evidence, appreciate the strong partisanship-background surrounding the controversy. It may then be left to the reader to say what weight one can or should attach to the evidence given or collected by these supporters of Walker's claim.

These Pioneers of the Transvaal Goldfields Association are: John Hunter McLea, J. L. P. Erasmus (both deceased), and Wm. H. Auret Pritchard, all of them strong partisans of the claim of George Walker. John Hunter McLea was the organiser and secretary of the T.G. Association. It was he who discovered George Walker in Krugersdorp in 1924, living in the most abject poverty. The story told by Walker was a pathetic one and touched the generous heart of McLea, who succeeded in obtaining a pension of £200 per annum for him from the Chamber of Mines, which was continued in favour of his widow, after his death on the 18th September, 1924. I should mention that, prior to this, Walker had succeeded in obtaining some £400, between 1912 and 1919, from the Miners' Phthisis Board, on the plea of his poverty and of his being the oldest miner on the Rand. He made no claim that he was the discoverer of the Main Reef.

J. L. P. Erasmus was an Attorney and Notary, closely associated with McLea. He was an active member of the T.G. Association and an enthusiastic supporter of Walker's claim. On the 13th July, 1924, he obtained a statement from Walker, this he edited, because Walker, although intelligent, was an uneducated miner. He likewise obtained a statement from George

Honeyball (Nov., 1935) and wrote and edited "A Brief Autobiography by George Honeyball, Discoverer of the Main Reef Leader" (1936). He also secured a statement from Willem Oosthuizen, Jr. (grandson of G. C. Oosthuizen) (April, 1936) and one from Godfray Lys (1935). An analysis of the stories told in these various statements discloses a bewildering number of irreconcilable contradictions. It would indeed be a waste of time to point these out. No reasonable or satisfactory inference can be drawn from them. They are not supported by any documentary evidence—and some of the assertions are fantastic, and palpable inventions. Hearsay and gossip are the foundation of these stories.

Wm. H. Auret Pritchard arrived on the Rand on the 22nd August, 1886. In a letter to me, dated the 17th September, 1946, he admits, that all his information about the discovery was obtained from Walker, and that he knew nothing of the other facts established by the official records prior to his arrival. That being so, the value of his evidence depends entirely on the credibility of Walker. Mr. Pritchard is a deeply religious man. The titles of some of his writings will indicate the trend of his religious beliefs, e.g. "The total eclipse of the sun and moon and its prophetic significance", "Are the Jews God's chosen people". etc. He even wrote a religious pamphlet on the Discovery, entitled "A parable: How gold was discovered on the Witwatersrand in 1886". George Walker is the central figure of this Parable. In it he says:

> "Having given a brief history of how payable gold was discovered, let me now proceed to adapt this wonderful and true story to the Gospel of Our Lord and Saviour Jesus Christ. . . . Just as Walker saw in that piece of outcrop of the reef the prospect of hidden wealth of a rich gold mine, so Christ saw in that blustering, swearing fisherman, Simon Peter, the prospect of a rich gold mine of faith and courage. Truly George Walker in stumbling over that bit of outcrop of the Main Reef on the 7th February, 1886, made a discovery that led to many fortunes—a wonderful illustration of those finding Christ as their Saviour and thereby inheriting the Kingdom of God."

There is much more of this. Walker's discovery is compared to Gospel revelation, and no one will ever convince Mr. Pritchard that "this wonderful and true story" could be an invention, because, otherwise, it would shatter the religious aura surrounding it. That is just human nature. Faith and belief are part of the inner soul of man and once accepted cannot be scientifically questioned or doubted. But we are concerned with mundane affairs and the realities of life and not with spiritual speculations. In the "Daily Mail" of the 25th February, 1926 ,Mr. Pritchard sought to strengthen his religious belief by commenting upon Mr. Struben's statement that George

Walker had found the Main Reef on Langlaagte, by saying: "Surely if anyone's word on this question can be relied upon, it would be Mr. Struben's." He failed to realise that the decision did not rest on the credence to be given to Struben's but to Walker's word.

Vanitas vanitatum! So convinced were Mr. McLea and Mr. Pritchard of the reliability of Walker's story, that in 1924 Mr. Pritchard had his photo taken standing next to the pedestal erected, on the 26th April, 1924, in honour of Walker, in Pioneer Park, and again, in 1926 he had a photo taken with his foot on the alleged outcrop that Walker is said to have stumbled over. Whether after 40 years of intensive mining operations it was still possible to identify or even locate the alleged outcrop is extremely doubtful.

The human memory is a tricky thing and wishful thinking is an unreliable factor to establish the truth. But it would be futile to attempt to convince Mr. Pritchard of this.

Mr. McLea again had his photo taken standing next to the gravestone, erected through his efforts, in honour of Walker in Krugersdorp Cemetery.

I should mention that Mr. Pritchard in his letter to me of the 17th September, 1946, makes the following important admission:

> "You seem to have gone to a great deal of trouble to prove that Harrison was by law entitled to the Discoverer's claim, as laid down by the Gold Law. I do not dispute that point and am prepared to agree with you there. But that does not constitute Harrison as the discoverer of the Reef—George Walker actually did discover the Reef. . . .
>
> "I hold, as you see, there is a wide gulf of difference between the man who in God's providence was led under strange circumstances to discover the reef on the ground and the man who merely, in a formal way, took out a licence for his claim and so established his right."

The attention of the reader is specially drawn to the fact that Mr. Pritchard does not accept the definition of "Discoverer" as laid down by the Committee. He regards the person as the "discoverer", who merely stumbles over an "outcrop", breaks off a bit and, in panning it, finds it to contain gold. In this popular sense, practically every prospector who finds a gold-bearing rock would be entitled to be called a "Discoverer". The Committee fell into the same error, and simply ignored the plain terms of the definition accepted, and failed to apply them to the evidence relating to Walker's stumbling over the alleged outcrop.

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FORECASTING THE WEATHER

BY

Col. N. P. SELLICK,

Rhodesian Meteorological Service.

Presidential Address to Section "A" of the South African Association for the Advancement of Science.

Read 2nd July, 1946.

It is customary for the President to put before the Association recent developments in the science in which he is particularly interested. In discussing meteorology there is no doubt that the greatest interest of people outside the science lies in the forecasts of the weather. I have therefore chosen this aspect as the subject of my address. In the practice of meteorology, particularly in the matter of forecasts, one is constantly encountering a serious lack of comprehension of the scope and limitations of the subject and it is felt that, before proceeding to discuss modern developments and their application to our countries it is worth while outlining the history and basic principles on which weather forecasting has been developed. In this outline reference is made from time to time to development in the United Kingdom. This practice is followed for convenience but it should be understood that parallel developments took place in other countries and all contributed to the results achieved.

The modern art of forecasting dates from the discovery of the principle of the barometer by Torricelli in the 17th century and the invention of the thermometer. Torricelli found that when a long glass tube closed at one end was filled with mercury and inverted in a bowl of mercury, the pressure of the air supported the column to a height of approximately 30 inches. It was inferred from this that the pressure exerted by the atmosphere was equal to that exerted by a column of mercury 30 inches high. Further observation shewed that the height of the column varied appreciably from day to day and that wet and stormy weather frequently accompanied a fall in the height of the column and fine weather a rise in the column. It was also discovered, as might be expected, that a mercury column set up in a high place was shorter than one set up at sea-level. Much later, Laplace stated the law relating altitude to pressure. This is known as the fundamental hydrostatic relation and remains perhaps the only theoretical law of meteorology which can be applied without misgivings to almost any problem.

The general relation between the height of the mercury column and the weather was seized upon and a considerable industry producing barometers with the familiar "Very Stormy-Wet-Fair-Very Dry" graduations was developed. Mercury barometers were arranged by Hooke to operate a hand moving over a dial. Later the delicate mercury and glass portion was replaced by an exhausted flexible metal box and the familiar aneroid barometer appeared. The common "Weather Glass" inscriptions are said by Sir Napier Shaw to be related to the weather in the latitude of London. The relation is by no means close and disappears over large parts of the earth.

The barometer itself was developed as a precise instrument for indicating atmospheric pressure, and regular records were made at various institutions. A study of simultaneous readings of barometers, reduced to sea-level by Laplace's formula, shewed that the fluctuations in barometer height were due to well-defined areas of low and high pressure moving across the country and, in the middle of the nineteenth century, Buys Ballot, a pioneer in the study of distribution of pressure and weather, enunciated his law—"If you stand with your back to the wind (in the northern hemisphere) high pressure will lie to your right and low pressure to your left." This law was received with great reluctance. It appeared obvious that air must flow from high pressure to low, and meteorologists would not accept the idea of flow normal to the gradient until later evidence was overwhelmingly in its favour.

The development of the electric telegraph provided a means for the rapid collection of information and early "Synoptic Charts" were plotted at the Exhibition of 1851 as a sequel to an experiment in electric telegraphy by the "Daily News" in 1849. "Synoptic" means a general view and a synoptic weather chart therefore gives a general view of weather over a large area. In the practice of forecasting the general view is taken at a particular instant of time and simultaneity of observations is usually implied when the term synoptic is used.

The application of weather forecasts to the protection of shipping followed the electric telegraph and official bodies were constituted to apply the meagre knowledge then available to this purpose. It rapidly became evident that the charts required for forecasting could not be confined to political boundaries and the first International Meteorological Conference was held in Vienna in 1873, largely to devise methods for the interchange of weather reports. This International Meteorological Organisation, mainly European until the 1920's, has survived wars and extended its scope and is now a very live world-wide organis-

ation directing the majority of meteorological activities of the world.

EARLY DEVELOPMFNT.

Development was very rapid at first and the state of knowledge obtained in a short time is admirably set out by Abercromby in his "Principles of Forecasting" published in 1883. He states, para. 1, "Every morning, at 8 o'clock punctually, telegraphed reports are sent up to London from about 50 stations in the United Kingdom, giving the height of the barometer, and of the thermometer, with the direction and force of the wind together with the actual state of the weather. Practically the weather changes are so rapid that these reports must be sent by telegraph to be of any use." The full sum of reports included 23 morning reports from the Continent and there was a small collection at 2 p.m. and another, sponsored by the "Times", at 6 p.m. The pressure and other weather information were plotted on a blank chart and "Isobars" or lines of equal pressure were drawn. An interesting point is that, as described, the pressures were plotted and isobars drawn before the winds were entered on the charts. This serves to emphasize the fact that Buys Ballot's law was still suspect. Now, with the theory of balanced motion established, no forecaster would attempt to draw isobars without the assistance of the winds.

Abercromby then devotes a short chapter to the empirical relations between wind and isobars, giving Buys Ballot's law and a table by Whipple relating the velocity of the wind at Kew to the pressure gradient. He then proceeds to set out seven well-defined forms of isobars, the cyclone, the secondary cyclone, the V-shaped depression, the anticyclones, wedge-shaped isobars, straight isobars and the col. The weather associated with each of these pressure forms is described in detail and he then states the principle, p. 36, "We have now described certain well-defined Forms to which almost every configuration of isobars seems referable, and we have also seen that, subject to local, diurnal, and seasonal variations, each part of every one of them has a characteristic wind and weather."

"Hence, at any time, if we know the position of a system belonging to any of these Forms, we shall be able to say what the weather is at the moment, at any part of the region over which the system extends." He then goes on to describe the movement and development of the "Forms". The direction of movement is generally from west to east averaging about 20 miles per hour but may reach 70 miles per hour to the east; the direction is occasionally towards the west. The direction of approach is also variable and four types are distinguished, the Southerly, Westerly, Northerly and Easterly, with varying weather sequences. Amongst other things, the possibility of extending the period of the forecasts by taking account of

depressions entering the Atlantic from America is considered and rejected on the evidence that important changes in velocity and character occur during the passage.

Abercromby's principles have been described at some length. They were quoted in full by Napier Shaw in "Forecasting Weather" in 1911 as giving the general ideas which had been employed in the past 35 years and, although modern forecasters would hesitate to subscribe quite so wholeheartedly to the exact correspondence of weather and pressure distribution, the third edition of the "Weather Map", the M.O. official publication on forecasting issued in 1939, still devotes a great deal of space to Abercromby's views.

Dynamic Relation between Pressure Gradient and Wind.

A most important development related the wind to the isobars. Ferrel developed the equations to motion of a fluid under pressure forces on the rotating earth. His argument appeared first in 1858 and was reprinted in 1882 as a Professional Paper of the Signal Service which controlled the weather bureau in the U.S.A. The equations are exceedingly complicated and appear to have attracted little attention from forecasters. At a much later date, probably as a result of study of "Barometric Gradient and Wind Force" by Gold and "The Life History of Surface Air Currents" by Shaw and Lempfert, Shaw was led to enunciate the principle that in general the air moved in a pressure gradient under balanced forces without accelerations. The application of this principle to the equations of motion simplified them very materially and it was possible to see that air, under the influence of the earth's rotation, would move parallel to straight or curved isobars with a velocity proportional to the pressure gradient. Wind moving parallel to straight isobars was called by Shaw a "Geostrophic Wind", and wind moving parallel to curved isobars and thus including centrifugal accelerations was called the "Gradient Wind". The cross component towards low pressure observed in surface winds was found to disappear at a height of about 500 metres above the surface and was attributed to friction.

This principle of balanced motion gave a dynamic explanation of Buys Ballot's law and of the relation of wind velocity to pressure gradient. It has been adopted as an experimentally verified fact and a forecaster to-day not only uses wind observations as a guide in drawing isobars but is quite prepared to apply the geostrophic wind relation to most points in a pressure field with confidence that the direction and velocity of the wind so derived will be reasonably near the truth. This may be one of the misfortunes of meteorology. It has been shewn by Jeffreys that in an atmosphere moving under balanced forces there can be no change with time. Pressure systems and winds must always be the same. In fact, all movement of pressure

systems, development and weather, the items of supreme importance to the forecaster, are due to unbalanced motion in the atmosphere which, with the present accuracy of observation, cannot be determined directly.

A further development of great importance is the use of isallobars. These are lines of equal rate of change of pressure with time. If a stationary depression were deepening, the rate of change of pressure with time would shew a centre of falling pressure near the centre of the depression. If the depression were moving, the pressure would shew a fall with time in advance of the centre and a rise in rear. Unfortunately deepening and moving usually occur together and no certain means is known of separating the isallobars due to the two occurrences except in retrospect. Brunt and Douglas, "On the Modification of the Strophic Balance, etc.," shewed by approximate methods that there should be an inflow towards an isallobaric low and presented an equation for calculating this "isallobaric" component of the wind. The theory has met with some acceptance as it leads to an inflow in advance of a moving depression, the area in which the existence of such an upflow is known from the cloud and rain normally present. This would appear to afford an indirect means of determining deviation from balanced motion, but the equation to the isallobaric component is approximate and there are occasions when the flow must be otherwise.

In practice the isallobars are based on the pressure change which has occurred in the last three hours before the time of observation and they are of great value in forecasting the movement and development of pressure systems in temperate latitudes. In sub-tropical latitudes the pressure changes due to moving systems are comparatively small and are masked by larger fluctuations due to variation in diurnal changes and precipitation, and no system has so far been worked out for their utilization in day to day forecasting.

A further development which may assist is attributed to V. Bjerknes. Classical hydro-dynamics deals exclusively with an incompressible fluid. The atmosphere is compressible and varies in density. Bjerknes considers a fluid with variable density and distinguishes two main cases: the "Barotropic" case in which surfaces of equal density coincide with surfaces of equal pressure, under which conditions a steady state exists comparable with the balance of motion dealt with earlier and the "Baroclinic" case in which surfaces of equal density are inclined to surfaces of equal pressure. In the latter case work can be done by gravity in bringing the fluid to a barotropic condition. A measure of the potential energy available is given by the number of solenoids present. A unit solenoid is bounded by two isobaric surfaces unit pressure difference apart and by two surfaces of equal density unit density apart. The atmosphere is quite definitely baroclinic and

two cases may be distinguished. In the first a horizontal section shews the lines of equal density parallel to the isobars. In this case the winds may balance the solenoids and achieve a steady state. In the second case a horizontal section shews the lines of equal density cutting the isobars, no balance can be achieved and development must take place. As will be seen later, modern analysis can indicate this condition.

Polar Front Theory.

It will have been noticed that weather forecasts are based entirely on empirical relations observed between the pressure distribution, which is not weather in the ordinary sense at all, and winds and weather. The principle of balanced motion provided a physical basis for the observed relation between winds and pressure and the next development came from Norway. During the first World War Norway was denied weather information by the belligerents and the meteorologists turned to a closer study of the local weather. The results of this study were given to the world after the war as the "Polar Front" theory. In a paper on atmospheric motions, Helmholtz had demonstrated the possibility of equilibrium being established between warm and cold masses of air separated by a sloping surface and had also discussed the formation of waves on such a surface. The Norwegian theory postulated that such a dividing surface existed between "Polar" and "Equatorial" air in each hemisphere and called the surface the "Polar Front". Waves developing on the front result in a tongue of warm air advancing against the cold air and ascending the frontal surface. The convergence due to the ascent sets up cyclonic rotation, cold air cuts into the warm and a cyclone develops. In the early stages two "Fronts" appear in the cyclone joined at the centre of lowest pressure. The warm front, extending to the east and south of the centre (Northern Hemisphere) represents a belt in which warm air climbs over a flat wedge of retreating cold air, the ascent of warm air producing a wide belt of cloud and precipitation. Behind the warm front lies the warm sector with warm air on the surface and behind this the cold front where cold air is overtaking and uplifting the warm air. This front also forms cloud and precipitation, but this time the cloud is of a convective type with thunder and squalls. The cold front moves faster than the warm and later overtakes it, lifting the warm air off the surface. At this stage the cyclone is said to be "occluded" and it begins to fill up although weather persists as the warm air is further lifted. A new front may develop between the cold air in advance and the overtaking cold air if the temperatures are appreciably different. The cyclone model thus presented fits the facts as observed with remarkable fidelity and provides the link between weather and pressure distribution. The fit is really remarkable

and reading Abercromby's description of cloud, weather and wind distribution in a cyclone, written in 1883, a picture of the frontal cyclone inevitably leaps to mind. The probable reason for its late discovery lies in the fact that most of the cyclones arriving in Europe are already occluded and their mechanism obscured. A noteworthy point of this mechanism is that it ties the weather to the fronts which are persistent material boundaries located in the air and travelling with it. Such fronts may be formed or destroyed by slow processes but they cannot move at rates inconsistent with the motion of the air in which they are embedded.

The Norwegian frontal cyclone, fitting the facts as it does, achieved rapid adoption by the majority of forecast services and has proved a powerful aid to forecasting, particularly short period forecasting. Such forecasts are required by air operators who, from the close of the first World War, have made increasing demands on the weather forecaster and are now by far the most extensive users of his services. The physical foundation of the frontal cyclone is not on the same footing as the wind and pressure gradient relation. The latter is founded on fundamental dynamic relationships, the former on observation, and all attempts to provide a dynamic explanation of the wave development have failed in the face of the enormous complexity of the system. The main contentions of the theory have stood the test of time. The existence of sensibly homogeneous air masses of great extent separated by more or less abrupt discontinuities of the nature of fronts is fully accepted and the existence of a frontal mechanism in the extra-tropical cyclone is undoubted. The continuous polar front has been abandoned largely in favour of the intermittent formation of fronts in areas where the circulation tends to bring warm air into contact with cold. The pressure distribution in such areas takes the form of a col, one of Abercromby's original seven types.

The Polar Front theory is particularly applicable to the temperate zone and attempts to apply it directly to the tropics have been disappointing. The frontal cyclone is probably a rare visitor to the Cape and the weather is more frequently affected by what appear to be trailing cold fronts which sweep in from the west and south after the passage of a "Family" of cyclones. On the other hand, the concept of large-scale quasi-homogeneous air masses has proved fruitful in the tropics and much of the weather forecasting is based on the argument of the characteristics of approaching air masses and the effect of insolation and orographic features on them. Without going into wearisome detail it is evident that cold air will in general contain less moisture than warm, that the former passing over a warm surface will tend to become unstable and will exhibit convective cloud and showers, whereas the latter, moving over a cold surface, will cool below and become increasingly stable, tending

rather to form fog and stratus cloud. Many changes may be rung on these arguments and, if soundly based and supported by upper air observations, they are of great value. Fronts in the Norwegian sense are rare in the tropics, but the meeting place of the trade winds, called variously the Inter-tropical Front, Equatorial Front or, better, the Equatorial Convergence Zone, is important and is referred to later.

The study of air masses is greatly assisted by the use of an energy diagram. Hertz and Neuhoff developed such diagrams on which the effect of changing pressure on a sample of moist air could be worked out. Later Sir Napier Shaw advocated the use of a modification of the temperature-entropy diagram. Many other diagrams have been put forward, but the meteorological version of the temperature-entropy diagram, usually called the Tephigram, is now approaching universal acceptance. It is not practicable to enter into details here, but the diagram is built upon a basis of ordinates of temperature and entropy. Lines of equal pressure appear as a series of slight curves. Dry adiabatics representing the adiabatic expansion or compression of dry air are the same as the lines of equal entropy, and wet adiabatics representing the changes taking place in saturated air when it is expanded are represented by another family of curves. A further family of lines indicates the saturation water vapour content of the air. On this diagram the results of upper air soundings may be plotted directly,—dry bulb temperature and wet bulb temperature against pressure. It is then possible to calculate with considerably accuracy the changes which would take place if the air were raised or lowered or heated or cooled from below. There are two very important applications of the tephigram to weather forecasting. One is the identification of air masses. The tephigram of an upper air ascent gives a clear picture of the general character of the air mass and also of the processes which have been taking place in it. For instance, an air mass in which divergence is occurring is characterized by inversions and weak lapse rates of temperature and it is generally dry. The lapse rate is the rate of fall of temperature with height. On the average, in the lower atmosphere, the air cools at a rate of 3°F. per 1,000 feet of ascent. The dry adiabatic lapse rate under which dry air can move freely up and down is about 5.5°F. per 1,000 feet. An inversion is a rise of temperature with height and frequently occurs abruptly in a shallow layer. A cold air mass heated from below shews very steep lapse rates and is also dry. Air within a deep layer of cloud has the wet adiabatic lapse rate. The second application is the determination of changes which will take place in an air mass due to diurnal variation of temperature of the surface layers. It is possible to assess the amount, height and type of cloud which will form in accordance with estimated changes of surface temperature and thus to

forecast thunderstorms. Regular upper air ascents at a number of stations is a new development and the interpretation of the tephigram is in its infancy. It has great possibilities which may be realised after further study.

Recent Advances.

Developments since the emergence of the Polar Front theory have been largely along two lines. First, the increase in reporting stations and increased frequency of reports, and, second, the improvements in observing the upper air. The demands of aviation have led to the introduction of four main synoptic charts distributed at six-hour intervals through the day; at important centres auxiliary charts divide the interval into three hours and many intermediate reports are received. The improvement in telecommunications has made possible more rapid and more extensive collections and detailed charts covering nearly the whole of the northern hemisphere and part of the southern hemisphere can now be plotted within a few hours of the time of observation. Stations have been set up on many islands and other unoccupied places for meteorological purposes and special ships are employed purely for weather observations. The greatest development has been in the upper air. The experimental " Radio-sonde ", an instrument devised to replace the aeroplane and kite for measuring upper air temperatures, has been perfected and many stations now make two or more observations a day obtaining temperatures and pressures and to some extent humidities for nine-tenths of the atmosphere. The pilot balloon utilised to determine upper winds in the lower layers of the atmosphere in clear weather, is now supplemented by a ' Radar " version which can be followed to great heights through cloud and weather and by radio fixes of the signals of radio sondes. The system of locating thunderstorms by atmospherics, pioneered by Watson Watt and Schonland, has been developed into ' Spherics " by which thunderstorms within a radius of hundreds of miles are located and plotted accurately several times a day. The ' Plan Position Indicator ", a radar device for locating ships at sea, has been proved equal to locating weather, and storms within a radius of fifty miles can be detected at a glance. Aircraft, specially equipped and carrying a trained meteorologist, make regular flights over the oceans to complete the weather picture.

These developments, accelerated by the war, have fulfilled the forecaster's dream and it is now possible to obtain by direct measurement the pressure, temperature, humidity and horizontal air movement through the greater part of the atmosphere. Most of this has occurred during the war and, although new

techniques have been adopted, the full utilisation of the data is not yet possible and the results have been rather disappointing in their effect on improving the extent and accuracy of the ordinary weather forecasts.

Three Dimensional Analysis.

The problem of three dimensional analysis of the weather situation and therefore of accurate forecasts covering a period of days is one of exceeding complexity. The mass of data at present available is staggering. An ordinary weather report taking up five words in a telegram contains information about high, medium and low cloud, including the height and amount of the latter, visibility, direction and force of the wind, past and present weather, pressure and its variation and temperature and humidity. A chart of Europe and neighbouring seas would contain reports from several hundred stations. All of these data are represented symbolically on a chart in "Station Model" form and occupy, for each station, a space of rather less than half the area of a penny stamp. The analysis of the chart by drawing isobars and fronts serves to organise the information and the whole becomes more or less intelligible to the forecaster without the necessity for studying individual detail. Add to this the numerous observations of upper wind and upper air temperature and humidity now required and the task of analysis is squared rather than doubled.

Practical three dimensional analysis is in its infancy and no doubt better methods of co-ordinating the data will be devised. At present an adaptation of methods advocated by V. Bjerknes in 1910 is in use. The main point established by Bjerknes was the superiority of pressure contours over isobars for representing pressure distribution. A chart of isobars represents a horizontal section through a pressure field, whereas a contour chart represents the height of a surface of equal pressure in the same way as a contour map represents the shape of a hill. The superiority of the contours lies first in the fact that the wind is related to the pressure gradient through density and similar isobar patterns at different levels therefore represent different wind velocities. This is liable to lead to confusion. Contours simply represent the slope along which gravity is acting on the air and the relation between contours and wind patterns is independent of density, thus similar contour patterns are accompanied by similar winds at any level in the atmosphere. A second superiority lies in the relative ease of calculation of heights of isobaric surfaces. Thirdly, all vertical columns between two isobaric surfaces are subject to the same pressure conditions and unit columns have the same weight; their lengths are thus proportional to their density or, very nearly, to their temperature. Lines of equal difference of height between two isobaric surfaces are called thickness lines

and are readily constructed graphically. When drawn they indicate the mean temperature distribution in the layer. Charts of contours and thickness lines present an approximate picture of the movement and temperature distribution of successive layers of the atmosphere. It is approximately true that steady conditions are indicated by parallelism between the thickness lines and contours, and development by an inclination between the two.

The scheme described above depicts the weather horizontally in layers. There is reason to believe that in lower latitudes the distribution of conditions in the vertical is of more practical importance. In the tropics the thunderstorm accounts for the bulk of the precipitation, and forecasting thunderstorms is very materially assisted by a knowledge of the temperature and humidity distribution in the upper air. The results of individual observations are plotted on a tephigram and it is possible to assess the amount, height and type of cloud which will form in accordance with estimated changes of surface temperature and thus to forecast thunderstorms..

All this development has contributed more towards improving the forecaster's understanding of events than to the accuracy of forecasts. A method of assessing the accuracy of 24 hour forecasts of wind and weather has been in use in the United Kingdom for many years. The accuracy was assessed at rather better than 75% in 1881 and by the 1920's had improved to 87%. At the same time regular general forecasts for periods exceeding 24 hours, called further outlooks, had been introduced with success. It will be interesting to see the post-war scores.

The production of a longer range forecast covering a week in advance and also a seasonal forecast has been the endeavour for many years. The present position is briefly that the extension of short range forecast technique is capable of achieving a considerable degree of success provided that the forecaster is at liberty to withhold his forecast when the situation is not clear. In other words, there are times when the run of the maps is such that the forecaster can see a long way ahead and there are times when little can be seen and silence is advisable. Such medium range forecasts are of great value but their irregularity is at times exasperating to the user. Another method, practised in the United States and also in Germany, is semi-statistical and aims at producing forecasts for five days to a week ahead regularly by methods differing considerably from argument from a synoptic chart. Several different approaches have been devised and much is claimed for them by some, but tests carried out in the United Kingdom during the war, when reliable medium range forecasts would have saved many lives and countless expenditure, gave unconvincing results.

Finally, there is the seasonal forecast. Its home is in India, a land of droughts and floods. The forecast is based on the examination of weather occurring previously in different parts of the world and by correlation with the series it is wished to forecast. The most likely factors are selected and combined in a regression equation. As is evident, the method is entirely empirical and is justified on the theory of probability. The forecast formula indicates, say, an excess of 15%, the probable error of the formula on past records is, say, 10%, therefore the probability of an excess is high. Sir Gilbert Walker, who devoted much attention to the subject, recommended the practice of issuing a forecast only when the indicated departure from normal exceeds the probable error. The forecast, which he prefers to describe as a 'Foreshadowing", indicates no more than a probability of excess or defect over normal and, if the forecast equation has a reasonably high correlation, forecasts would be issuable on 50% of occasions with a four to one chance of success.

As one of the few surviving practitioners of seasonal foreshadowing I quote the results for Southern Rhodesia. The equation was calculated in 1928 on 30 years' records and has factors — Nile Flood, Rio Pressure, Mauritius Temperature and Bulawayo Temperature. The forecast for the season October to March is available on the 2nd December. The table below shews the results:—

Season.	*Actual Departure.*	*Estimated Departure.*
29-30	—1.9	—1.2
30-31	—4.5	—5.3
31-32	+1.5	+6.1
32-33	—3.7	—7.6
33-34	—4.2	+2.6
34-35	—0.6	+18.3
35-36	—2.8	+0.1
36-37	—0.9	—1.8
37-38	—5.0	—6.7
38-39	+12.2	+11.8
39-40	+3.3	—4.8
40-41	—2.3	—4.3
41-42	—5.9	—7.9
42-43	+3.9	+13.2
43-44	+2.5	+13.3
44-45	—3.9	+1.1
45-46	+1.5	—3.6

The standard error of the equation was 5.3 ins. and on Walker's criterion a forecast should be issued when the indicated departure exceeds 3.5 ins. This occurred on 12 occasions and of the 12, 9 were successful. The years of maximum excess

and deficit were correctly indicated. In spite of this the correlation has fallen considerably and the equation must be revised.

Forecasting in Southern Africa.

Turning now to Southern Africa, daily weather forecasts were introduced by the Transvaal Meteorological Office on 1st July, 1906, and described by R. T. A. Innes in a paper entitled "The Barometer in South Africa" read before this Association. In the course of the paper he stated: "I consider that a very great obligation rests on the shoulders of Government meteorologists in South Africa. The lot of the farmer in this semi-arid country is not to be envied. It therefore behoves us to do our utmost to assist him in his work by providing him with the most accurate forecasts that science can furnish It seems to me that it will soon be in our power to do so with an accuracy unknown in Europe and America, and if I am right in this opinion let us consider the effect. It is safe to say that it will improve the farmer's chances of success by 25%." Naturally the attempt was made to apply overseas experience to South African conditions and grave difficulties were encountered at the outset. Innes touched on some of these. He found that the number of barometric stations available in the interior was hopelessly inadequate and that, of the few existing, only the instrument at Johannesburg was at a known height and possessed a known index correction. Isobars have generally represented the pressure at sea level. For barometers situated within 2-300 feet of sea level the application of a simplified Laplace formula gives the reduction to a high degree of accuracy, for barometers situated on the South African plateau, 4-5,000 feet above sea level, this is not the case. The effect of temperature on pressure reduction, over a range of 3,000 feet, is to alter the computed pressure by 0.2 mb. for every 1°F. alteration in the temperature of the column. When a pressure is computed in a real air column the actual temperatures prevailing at the times are measurable and the pressure can be computed with a high degree of accuracy. When it is desired to compute the pressure at sea level below, say, Johannesburg, the case is different. In place of an air column there is a mass of rock and the desired pressure is fictitious.

Weather services in South Africa, wedded to the idea of sea level isobars, got over the difficulty by adopting a scheme of reduction of pressure devised by Bigelow for American plateau pressures. In this method the temperature of the fictitious air column is assumed to follow a seasonal trend regardless of the changes which actually take place from day to day. The method has the virtue of minimum distortion of the plateau pressures but its unreality leads to the toleration of inaccurate pressures and introduces unreal variations be-

tween plateau and coastal pressure as warm air replaces cold and *vice versa.*

The introduction of routine forecasting led to the establishment of a better network of stations and more reliable determination of heights. The latter problem is still very much to the fore. The normal unit of pressure is 0.1 millibars and is sensitive to a variation of height of 3 feet. The published rail levels in the Union are known to err by as much as 160 feet and even when corrected for all known errors do not inspire full confidence. Further, the railways do not extend to all points where pressure readings are desirable. Lest the railway engineers arise in their wrath, I must explain that the errors referred to are not errors of survey but are largely due to a habit of selecting arbitrary levels for particular surveys. Somewhere in or north of Pretoria trains rise about 160 feet according to the published levels without any particular expenditure of effort on the part of the locomotive. A line of precise levels runs from Cape Town through Pretoria to Lourenço Marques and has lately been extended to the Rhodesian border. The heights of stations along this line are satisfactorily determined. Apart from this chain the meteorologist is dependent on corrected rail levels, the sea itself and the expanding tertiary triangulation which is estimated to be correct to about 5 feet. For stations remote from these aids the heights must be calculated meteorologically, a system which rather begs the question.

Synoptic charts in South Africa, growing slowly in spite of these difficulties and the added trouble of lack of communications, were found to differ somewhat radically from those of Europe. The procession of cyclones familiar to Europe either passed far to the south or had no existence and the very close relation between pressure distribution and weather claimed by Abercromby was not markedly in evidence. Much of the weather in the interior was not obviously related to pressure patterns. Forecasters made the best of the information available and built up a system of forecasting applicable to the observed South African pressure variations. Much of the forecasting technique remained personal and no manual of forecasting has so far been published, although a statistical study of South African pressure types and accompanying rainfall appeared at the outbreak of the late War.

When weather forecasts were initiated in Southern Rhodesia in 1922 the case was even worse. The railways do not cover the country and their heights were very uncertain. There was also a vast meteorological blank to the north and west. C. L. Robertson, who was charged with the work, followed South African practice but owing to the uncertainty of barometers and their heights he adopted "Pressure Difference from Normal" as his main forecast chart and shortly added a chart

of 24 hour pressure change. He also charted the tracks of centres of highest and lowest pressure departures from normal. Rainfall for the succeeding 24 hours appeared to shew fair correlation with the pressure distribution and a preliminary classification of eleven deviations from normal pressure types and their associated weather was presented to the Rhodesian Scientific Association by Robertson in 1926. The classification was continued by the present writer with disappointing results. The types tended to multiply and the weather associated with each type to become more varied and the matter was dropped. In 1928 experiments were started with charts shewing the pressure distribution at 1,500 metres instead of sea level. These charts were an improvement and, after three years' experience, the plotting of deviation from normal pressure charts was dropped and all forecasts were based on the 1,500 metre isobars. The pressure distribution at 1,500 metres over the South African plateau is largely real and the reduction of plateau pressures to this height is generally through a small column. In consequence a higher standard of agreement between neighbouring stations is expected. These charts quickly shewed up errors of level and barometer at individual stations and resulted in a general revision of heights and replacement of barometers. The Surveyor-General and the Rhodesia Railways co-operated and a value for the railway bench mark at Salisbury based on mean sea level Beira was agreed upon and all levels referred to this point. The precise level chain from Cape Town is now well into Rhodesia and indications are that the close, when the chain reaches Salisbury, will not require more than a minor adjustment to the adopted datum. The case in Northern Rhodesia and Nyasaland is bad and offers no practicable solution at present.

This change over to forecasting on plateau level isobars is logical. It is now perfectly clear that the close relation between pressure and weather is accounted for by the relation between pressure and wind and there can be no doubt that theoretical sea level isobars below a plateau are only significant in so far as they resemble the real isobars on the plateau.

The system of forecasting based on high level isobars was described by the writer in a published paper read before the Rhodesian Scientific Association in 1934. In this paper reference was made to the use of dew points as an aid to forecasting and early attempts to apply the air mass and frontal theory were discussed. At Lusaka in 1936 it was generally agreed to adopt the level of 1,200 dynamic metres as the datum for all plateau pressures in Southern and Central Africa, and East African and Rhodesian charts have been drawn at that level ever since. In the Union pressure charts at sea level were maintained until after the outbreak of the War. Various experiments

were then tried and finally a bi-level chart, isobars at 1,200 dyn.m. over the interior and at sea level over the oceans, was adopted. Again the real high level isobars indicated a number of anomalies in accepted pressures and led to an intensive campaign of adjustment of levels and barometers. At some date it is probable that isobars will be replaced by contours of, say, 1,000 and 880 millibars, thus achieving uniformity of gradient and wind velocity.

The South African Meteorological Service in the War.

Before going on to discuss current and future problems of forecasting in Southern Africa I propose to give an outline of the work of the S.A.A.F. Meteorological Section which it was my privilege to command during the late War.

At the outbreak of the War the Union Meteorological Service operated one forecast office which was open for limited daylight hours in Pretoria and about ten aerological stations along the main air routes manned by one or more men trained as observers. The office at Cape Town issued some forecasts based on limited data. The interests of the forecasters were largely confined to general weather in the interior and to the coastal strip.

The first war demand was from the Royal Navy, which required that collective reports for South Africa and forecasts for the neighbouring ocean areas be issued several times a day by radio and that forecast offices be opened at the main ports from Walfish Bay to Durban. Further, all weather reports and forecasts were to be kept secret. The Navy assisted materially in establishing this service by bringing out Naval Meteorological personnel from England to man a forecast office at Simonstown and by recruiting locally and in Rhodesia to man forecast offices at Walfish Bay and Durban.

Towards the end of 1939 the Department of Defence, which had assumed control of the service, decided to establish a military formation to work in co-operation with the Naval Service and to provide all facilities required by the war and by air. The command of the unit was offered to me and work was started with a handful of volunteers from the Union Meteorological Office. The unit set out, with a uniformed strength of one forecaster and rather more than a dozen observers, with the assistance of the Naval Service, to carry on the services and recruit and train about twenty forecasters and forty observers. These numbers were then considered necessary to carry out all the work. As the first recruits completed their preliminary training the Union embarked on the East African Campaign and it was necessary to draft a considerable proportion of them to East Africa. Before the end of 1940 the Union undertook the Empire Air Training Scheme and the paper strength of the unit, originally about 70, rose

to over 300. Fortunately the Air Ministry sent out a few trained meteorologists with certain transferred schools. Recruits came forward freely in the early stages, although there was always a dearth of trained physicists. Training was the great difficulty. The Naval Service assisted with the forecasters by lending an officer, who put them through a course usually given in England to R.N.V.R. Meteorological Officers. In the absence of any text-book or co-ordinated notes on forecasting in South Africa and with the dearth of practical forecasters little or no training in local conditions could be provided. Observers were farmed out for training to stations all over the Union and Rhodesia.

As part-trained observers became available stations in the Union and South-West Africa were manned and the long sought station at Tristan da Cunha was set up in co-operation with the Navy. The Air Force was brought under contribution and regular meteorological flights instituted at points with air establishments. Some information was also obtained from operational flights over the sea and for a time special meteorological reconnaissances were made to 500 miles south-west of the Cape. These were only made twice a week for a short period but proved extremely valuable.

At the height of its effort in 1944/45 the unit was operating over thirty stations in South Africa on a day and night basis; including three naval stations, a twenty-four hour forecast service was being provided at sixteen offices and a number of others were providing forecasts by day and at times by night. In connection with the Air Training Scheme over a thousand meteorological lectures were being delivered a month to pupil air crews and a training scheme handling up to twenty forecasters and forty observers continually was in being.

Outside South Africa the Section maintained a unit through the East African Campaign and moved to Egypt with the S.A.A.F. Here an established but weakly manned meteorological detachment of the R.A.F. was encountered and the Section's efforts supplemented theirs. Lessons on mobility learned in East Africa bore fruit in the Middle East and two mobile units of the Section met in Benghazi on the second advance to the west. The first wholly South African mobile forecast unit was established in 1942 to serve 3 Wing, S.A.A.F. It took part in the retreat to Alamein and was the most advanced meteorological unit in the defence of that place, serving R.A.F. and S.A.A.F. units impartially and receiving a compliment from the A.O.C. This unit accompanied 3 Wing in the advance to Tunis, across to Sicily and thence into Italy, where it was joined by two newly-formed S.A.A.F. forecast units and was finally disbanded in North Italy. At V.E. Day there were over a hundred members of the Section actively employed in the Mediterranean Theatre of Operations.

The Section, at the invitation of the Naval Commander in Chief, assisted in East Africa during the trying time of the Japanese advance and was the sole meteorological unit to take part in the Madagascar campaign, where contact was rapidly made with our French meteorological colleagues and the service re-established within a very short time of the occupation.

Throughout the War, from the opening of the East African Campaign until the last troops had returned from Helwan, the Section was engaged in providing a weather service along the Central Air Route. For a time the whole route from Zwartkops to Nairobi was operated by the Section; later most of this was taken over by the R.A.F., but finally, during the withdrawal of the South African Forces from the Mediterranean, details of the Section were at every point from Bari and Castel Benito to Zwartkops.

Certain meteorological lessons may be drawn from this war experience. Perhaps the first is the advantage of formal training for forecasters. It proved possible, with suitably selected candidates, to turn out reasonably trained forecasters within 18 months or two years. The course of training included instruction and practice as observers, whose duty included plotting of synoptic charts followed by an intensive course lasting three months, the first two of which were occupied in meteorological theory and plotting and analysis of a graduated series of charts and a few weeks of practical instruction under a competent forecaster. Candidates were then sent to a forecast office as dependent forecasters and were usually pronounced competent after six months' experience. The standard of competence may be considered satisfactory, as many forecasters so trained served in operations with R.A.F. units and were universally accepted. When public forecasts were resumed in 1945 an accuracy of 80% was attained by the three coastal offices, largely manned by war-trained forecasters. In regard to observers it appeared most satisfactory to provide a sound grounding in the work first and after experience at a station to provide an advanced course later. This served to some extent as a check on the establishment of local practices and thus to achieve uniformity.

Women were introduced into the Section at an early date. It was proved that they make competent observers and will carry out certain routine work better than men. It is unusual for women to take up the mathematical-physical side at University, but a small number of women with degrees were trained as forecasters and two achieved considerable success. There seems no reason why women with a bent for the mathematical sciences should not take up meteorology as a professional career.

The building up of a considerable forecast service in the Union was gravely handicapped by the absence of any standard

work on the climate and weather of the country, and the lack of papers on forecasting. An attempt was made to produce a work on climate and the whole of the coastal belt was covered during the War. Detailed studies of the weather at a number of points were completed, but it was impossible to produce a textbook on forecasting. The information is now available for the production of these works and they should be undertaken without delay.

A final lesson is that a country cannot maintain an efficient forecast service in the midst of backward neighbours. The Union is bordered by vast oceans almost devoid of shipping and must have recourse to the few available islands. Tristan da Cunha, supported by observations from stations on southern islands and the Antarctic continent in the neighbourhood of South America and from South America itself, proved invaluable, not only for ocean analysis but for understanding and forecasting the weather along the coast and in the interior. There is no doubt that a second station on Gough Island would be of great value and it is probable that reports from Marion Island would also assist. South-West Africa and Bechuanaland Protectorate are not in a position to maintain a reasonable network of observatories, but the information is essential to the forecaster in South Africa. If forecasting is to be developed to a high standard it will be necessary for the Union to establish and maintain the stations necessary in these territories and also in the sparsely inhabited north-western Cape.

WEATHER SYSTEMS IN SOUTH AFRICA.

Now, to return to forecasting in South Africa, it may be taken as proved that the close association of pressure distribution and weather observed in temperate latitudes is not wholly supported by South African experience. I think the cause for this is not far to seek.

The weather in the belt of latitudes covered by South Africa is dominated by the two anticyclones which lie over the South Atlantic and South Indian Oceans. On mean monthly records these anticyclones are elongated areas of high pressure which extend from South America to our west coast and from Madagascar to Australia. They shew little movement with the seasons, the axes remain slightly south of 30°S., but the pressure is higher in winter and, joining the winter anticyclone over the Transvaal, a belt of high pressure extends right over the country. In summer the weaker pressures allow a break in the belt over the western side of the sub-continent. Conditions in these ocean anticyclones have not been fully explored; for example, it is not known in how far the monthly mean picture represents the daily state, but it is known, from the work of the German survey ship "Meteor" and from other observations, that the air mass of the anticyclone consists of two distinct parts. On the surface

there is a shallow layer of moist, cool, cloud-bearing air of an average depth of about 4,000 feet. This layer is surmounted by a great mass of warm, dry air of unknown vertical extent. There is an inversion of temperature between the layers and the amount of the inversion is related to its height. Off the coast of South-West Africa the inversion is very low, almost on the surface, and rises of 15°F. or more are the rule. The general inversion at normal heights is nearer 5°F., and in the trade winds, as they approach the equator, the inversion rises and disappears.

There is every reason to believe that similar conditions exist over the Indian Ocean and it is evident that South Africa lies in a belt of air in which rain is normally of trifling amount.

The trade winds from both hemispheres enter the Equatorial Convergence Zone with a high moisture content and with the inversion eliminated. The air in this belt is therefore eminently suited for producing rain. Like the polar front, the equatorial convergence belt is not continuous. Much of the air from the Indian Ocean sweeps across the equator in our winter to form the Indian South-West Monsoon and we receive in return a flow in summer, which unfortunately has a comparatively short sea passage and is not highly charged with moisture. In general humid equatorial air is too remote from us to be of interest in winter, but its normal habitat in summer is probably the Congo Basin and Northern Rhodesia.

To the south of the belt of anticyclones lie the "Roaring Forties", a belt of westerly winds extending from 40° to 60°S. This should, by analogy with the northern hemisphere, be the home of the frontal cyclones and there is evidence that something closely resembling families of cyclones pass frequently in these latitudes. A family of cyclones, according to the Norwegian theory, form in succession on the Polar Front and with the passage of the last of the family the polar air breaks out towards the tropics. The southern cyclones, which I intend to call "Southerly Lows", pass from west to east with their centres well to the south of the Cape. It appears likely that they follow more northerly courses in winter than in summer, but in general their effect on South Africa is the passage of an inverted V-shaped depression across the country. The southerly or open portion of the V moves fast, whereas the northern portion moves slowly or not at all, and the effect is that the axis of the V rotates from north-south to west-east. The passage is also accompanied by the formation of the mysterious "coastal" lows which are responsible for much of the local coastal weather, particularly in winter. The departure of the last of a family of southerly lows is accompanied by an invasion of cold air.

This general statement and what follows is my own opinion and would not be followed by all forecasters in every respect.

The winter rains, largely confined to the Cape, appear to be directly due to the southerly lows and their associated coastal lows. The moisture-bearing air probably comes from the southern boundary of the Atlantic Anticyclone and curves northward and then southward in its passage. East of the Cape the wet north-wester is replaced by a dry north-wester from the interior and little rain occurs. The air of the "Cold Snap" must originate far to the south. It comes up behind a family of southerly lows and sweeps over the country rather in the manner of a spent wave on an uneven beach. The first assault is from the west and the air may pass across the country, diverging and descending until it reaches the eastern interior in an extremely dry condition. Meanwhile the main body of air passes round the coast and, sweeping past Durban as a southwester, pours into the country *via* the Limpopo valley and over the Northern Drakensberg. The air which passes round the coast is cold and picks up moisture and heat from the ocean. It gives squally winds and sharp showers and occasional snow in the South-West Cape and much orographic cloud and some precipitation in Natal and in the mountains of the Transvaal, in Southern Rhodesia and Nyasaland orographic cloud and drizzle also appear. It is probable that some of the air which enters *via* the east coast has come from south of Madagascar. In winter the air is moisture-laden in comparison with the air it displaces and it is also unstable, so that its appearance is associated with cloud and sometimes with precipitation over the interior.

In general there is a marked discontinuity between the lower layers of air round the coast and that in the interior. In consequence when air from the ocean invades the interior we have cold weather and when air from the interior reaches sea level we have the "Berg" wind.

As summer approaches, the high pressure belt over the plateau weakens and the way is opened for the V-shaped depressions to draw air from the tropics. It is my view that this does not happen all at once. A succession of depressions draws the air further and further south, but each cold air invasion sweeps it back. Thus the pressure pattern in itself does not represent weather: a time and travel factor is involved and one is reminded of the moods of the weather, well known in England and remarked on by Sir Napier Shaw: "After a dry period, the weather sometimes seems unable to rain even after barometric conditions which are apparently most favourable for it, and on the other hand, rain sometimes falls without any recognisable meteorological reason, even, as we have seen, in the central region of an anticyclone. The peculiar 'mood' or 'fit' of the weather is a great difficulty for the forecaster." I think these moods are far more prevalent in South Africa than in England and that the explanation lies to a considerable

extent in the fact that rain bearing air must be coaxed into the country from afar. A system of following this air by dew points, weather and general pressure types was developed in Rhodesia in 1929 and I well remember the excitement of some forecasters under training in Pretoria who tracked this air into the North-West Cape and observed the cataclysmic outbreak of rains that followed. This method of tracking is very hit and miss and could now be replaced by the plotting of trajectories of the upper air and actual observation of changing upper air conditions.

In the early season the air drawn in is not very humid and precipitation is confined to a narrow belt associated with the trough of the depression. Later widespread outbreaks of showers occur in the air in advance of the trough and frequently, mostly in Rhodesia, the convergence zone itself appears in the country and may give prolonged spells of cloudy weather and much rain. When in Rhodesia, the convergence zone lies between northerly to westerly winds to the north and south-easterly to easterly winds to the south and has a width of a hundred miles or more. The wind circulation and rain mechanism in the zone is obscure owing to the lack of upper air observations due to the prevailing overcast weather. It is clear, however, that there must be considerable convergence to account for the rain and the presence of widespread altostratus cloud, from which the rain falls, is possible evidence of frontal action.

Now it has long been known that the greater part of the precipitation on the plateau occurs with rising pressure and it has recently been shewn that the main rises and falls of pressure take place simultaneously over the whole of Rhodesia, an area extending from 8° to 22°S. and from 23° to 33°E. These rises and falls have a considerable amplitude in the south and are quite small in the north. The general variation in pressure is thus consistent with the removal and replacement of air from the south and quite inconsistent with the travel of pressure systems through the area. We obtain a picture of a passing southerly low taking a large contribution of air from the southern part of the plateau. This is partly made up by contributions in diminishing quantities from further north, thus the air on the whole takes a step to the south, a large stride in the latitude of the Cape and a very small one in Northern Rhodesia. On the retreat of the low there is an inflow of air from the south and the reverse process occurs. If this is the general mechanism, then divergence occurs with falling pressure and convergence with rising pressure and the occurrence of precipitation with rising pressure is accounted for. It also accounts for the alternations of weather which occur within the same air mass in the absence of fronts and travelling pressure systems. It appears likely that the weather in the south is most frequently associated with travelling

pressure systems and fronts, but that further north this mechanism is replaced by alternating divergence and convergence.

I trust it will be understood that far more has been left out than included in this very brief description of South African weather processes.

FUTURE OF FORECASTING IN SOUTH AFRICA.

If one thing is clear in the history of weather forecasting, it is the increasing cost of providing improved services. Meteorology has largely developed as a State service and does not sell its wares. An exception to this appears in the United States, where the leading air operators have found it worth while to establish their own forecast offices working largely on basic information supplied over the official Weather Bureau teletype network and where at least one private practitioner, working on similar lines appears to have found the occupation of selling weather forecasts sufficiently profitable to encourage him to set up a parallel organisation in London.

It may have been noticed that Abercromby, quoted above, almost apologises for incurring the cost of telegrams in collecting weather reports. In his time the equipment of an observatory and the observations required were very simple. I have a quotation, dated 1898, from a well-known firm offering full equipment (including spares) for a meteorological station for £28 5s. The simplicity of the observations was such that part-time observers could readily be trained and a round of observations was completed in a few minutes. In England to-day the central forecast office has a very large room full of teleprinters collecting and distributing reports and forecasts and is in continuous touch with a large number of stations in the British Isles and, I think, with Paris. A modern first-class upper air observatory putting up two radio-sondes per day and following the balloons with radar would require a proper site and buildings and the ground equipment, costing thousands of pounds, would require highly skilled maintenance. A minimum staff of four would be required for one and a half hours for each observation and upwards of £15-20 per day of expendable equipment would be used.

It is evident that the days in which a weather forecast service could be run for a few thousand pounds a year have gone and as taxpayers we should consider the cost against the benefits. As a guide to the service at present expected we may take the recommendations of the meteorological sub-committee of P.I.C.A.O., a body which has been formed to lay down international standards for the meteorological protection of civil aircraft. The operation of such a service in the Union would cost something of the order of £200,000 per annum. Against this I set a rough and, I think, high estimate of 100,000 fare-paying passengers per annum carried by air, and the cost of insurance

against weather hazards is rather high. I hasten to add, from bitter experience, that the cost of protecting one air service per day is little less than that for fifty services per day. Would that the Exchequer saw this. On the other hand, the service required for air would provide daily forecasts of an accuracy probably rising to 90% and should in a few years be able to issue reliable forecasts for several days ahead. I saw recently in the Press an estimate that the annual production of crops and animals in the Union is valued at 100 million pounds and, disregarding Innes's rather optimistic estimate, it is quite reasonable to assume that weather forecasts, intelligently applied, would improve the yields and prevent losses by, at the very least, 1%. This would make the forecast service a very profitable investment for the country. I have not included the General Public in my estimate and leave it to the audience to decide whether a reliable forecast service would be worth the modest outlay of 2s. per head per annum.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 60-65, July, 1947.*

FRUIT, ITS PURPOSE, PROPERTIES, PRESERVATION AND PRODUCTS

BY

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Presidential Address to Section "B" of the South African Association for the Advancement of Science.

ABRIDGED.

Read 3rd July, 1946.

Introduction.—The word fruit does not allow of any strict and narrow definition, particularly if it is associated with the word vegetables, one class merging into the other, and the choice of either class being a matter of custom, as for example the classification of rhubarb as a fruit and tomato as a vegetable.

Purpose.—It can, I think, be accepted that in the main the purpose of fruit is the propagation and perpetuation of the species of plant which bears it.

Man, in producing fruit for his own requirements, has not only built up an organised cultivation, but by such means as weed removal, seed selection, irrigation, grafting and soil fertilisation, has caused the plant and the fruit to improve. This policy has now become indispensable for satisfying the growing needs of mankind.

Properties.—Fruit can be classified in general terms as succulent, saccharine and acid; with few exceptions it contains an average of 80% of water. The solids are largely in solution in the juice or in suspension as pulp, but the area of distribution may be general or confined, depending on the physical structure of the particular fruit, a feature which varies enormously.

In the orange, for instance, the juice is confined to a separate inner section of the fruit, from which it may be expressed by pressure of the fingers, whilst in the apple and similar fruits, the juice is common to the whole fruit and very powerful pressure is necessary to extract it, the remaining collapsed structure, called the pomace, being tough and leathery.

In reporting the analysis of fruit a rough classification of its important constituents must be adopted, as there is no agreed classification.

The analysis would generally be conducted by first drying the sample and reporting moisture and total solids, and the solids would then be reported either on the dry basis or on the whole original sample under such headings as: Protein, carbohydrate, acids, fibre and ash, the carbohydrates being split up under starch, sucrose, reducing sugars and cellulose, the acids separated as citric, tartaric, malic, etc., and the ash accounted for under the usual mineral headings. The form of analysis and the figures reported will depend on the purpose of examination whether medicinal, dietetic, flavouring, or other.

The classified constituents of fruit may be arranged as in the following analysis of ripe apples, viz.:—

Water	Total Solids	Malic Acid	Total Sugars	Invert Sugars	Sucrose	Starch	Ash	Undetermined
80.36	19.64	0.65	14.51	7.70	6.81	0.17	0.27	4.04

The undetermined constituents would cover woody fibre (cellulose), pectin, aromatic and flavouring materials, astringents (tannins), and if the seeds were included, also nitrogen and fats. The presence of oil or fat is usually confined to the seed, but there are notable exceptions, such as the olive and the avocado.

Carbohydrates.—The principal carbohydrate of food value contained in ripe fruit consists of sugars, while starch may preponderate in the unripe fruit and still be present to a considerable extent in the ripe specimen. Thus the food calories of most fruits are provided in the first place by sugars, and also by starch.

The change of starch into sugar, by ripening, can be illustrated by the banana. Hard and green, its sugar content is practically nil, whilst calculated on the dry basis, starch is approximately 70% but diminishes to nil in the overripe sample, while sugars advance to 50%.

Among primitive peoples, before sugar became a concentrated, refined article of commerce, its place was largely supplied by honey and by fruit.

As a class, fruits are notably non-nitrogenous and while it is true that the high valuation placed upon fruit in the diet is due to many factors other than its feeding and calorific values, those values exist and are often considerable.

Apart from the digestible carbohydrates, sugars and starch, there are those which pass unchanged through the digestive tract, such as cellular tissue, membrane, fibre, etc., which consist essentially of cellulose, add volume to food and stimulate the peristaltic action of the digestive tract.

Another compound of Carbon Hydrogen and Oxygen, often referred to as protopectin or pectose, occurs in quantity varying from traces to high percentages as an insoluble substance, probably serving as a filler in the cellular framework of fruit, from which soluble "pectin" can be extracted by hydrolysis. The importance of pectin in processing and preserving consists in the production of a set jelly in the presence of sufficient sugar, the degree and texture of the set depending on the relation of the factors: sugar—pectin—acid. It is now obtained from apple pomace or citrus culls as a light-coloured powder of a guaranteed strength.

Acids.—The acids present in fruits vary greatly in amount but consist in the main of citric, tartaric and malic acids, but many others have been found in small amount. They not only play an important part in the plant economy, determining the pH of sap and fruit juices, but they perform a similar important role in manufacturing processes. The acids have also a marked effect on flavour.

Flavour.—The factors responsible for flavour may be roughly grouped as esters, aldehydes, alcohols, terpenes, astringents, etc., superimposed on a background of sweetness and acidity. Some fruits, e.g., apple, pear and quince have a single flavour throughout, others may have two or more flavours in different parts as the citrus group have in pulp and peel, and others may have a strictly localised flavour, such as existing in the granadilla in the pulp around the seeds. Cooking always changes the flavour of fruit and the more delicate the flavour, the more it is distorted or actually destroyed by heat processing, a fact which has to be taken largely into account in the preservation processes adopted for such fruits as citrus and granadilla. Attempts have been made to identify and synthetise the constituents of many flavours, with various degrees of success.

Other Constituents.—The mineral constituents of fruit are undoubtedly important, but the dietitian looks more to cereal and vegetable intake for the supply of these, than to fruits.

Place in Diet.—One of the most important functions of fruit in human diet is the supply of the antiscorbutic food accessory factor, ascorbic acid or vitamin C. Citrus, tomatoes and guavas are rich sources of this substance, but, whilst citrus juices and fresh green vegetables have long been used to prevent and cure scorbutic conditions, the consumption of fruit is now recognised as a necessity for the prevention and eventual elimination of such deficiency diseases as scurvy, beriberi, etc. Fresh fruit (which may contain an average of 80% of water) has, with few exceptions (e.g., avocado, olive), no high value of calories per

pound, but dried or processed fruit, being concentrated or reinforced, as will appear from the following table, is in a different class:—

Calories per lb.	Edible Portions of Fruit Only.
100	Tomatoes, Rhubarb, Watermelon.
200	Grapefruit, Lemon, Orange, Peach, Pineapple, Raspberry, Strawberry.
300	Apple, Apricot, Blackberry, Pear, Canned Fruit.
400	Bananas, Cherries, Grapes, Plums.
1000	Avocado (contains 20% fat and 2% protein).
1100	Ripe Olive (contains 25% oil).
1400	Dried Fig, Prune.
1500	Dried Date, Honey, Marmalade, Jam.
1600	Raisins.
1800	Sucrose.

The main function in the diet of fruit and its products is that of augmenting our basic proteins, fats and starches; rapid release of energy from glucose, appetite promotion and digestion stimulation together with the laxative properties of some acid fruits should be noted.

Preservation of Fruit.—The processes in use may be broadly classified as follows:—

(1) Fresh fruit preserved in as nearly as possible its natural state, colour and flavour without any addition, by refrigeration. Great developments are in progress in fruit refrigeration both industrially and domestically, much research having been carried out on the best condition of the fruit for preservation and on methods, temperatures, packing, etc.

(2) Preservation by drying or dehydration. Most of the advances in wartime dealt wtih the preservation of colour and flavour and the prevention of enzyme action. Mechanical dehydration has been mainly used for *meat* and vegetables and it is presumed that fruit is still largely dried in the sun, in many cases with or after treatment by SO_2.

(3) Preservation by the use of approved chemical preservatives. Although fruit flavours are impaired or destroyed by heat treatment, they may to some extent be preserved, especially in juices, by a very rapid and brief application of heat, known as "flash pasteurisation", provided that the container is hermetically sealed under vacuum, and the contents consumed shortly after exposure to the atmosphere. In warm climates sweet sauces and fruit juices are subject to rapid fermentation after the container is opened, for the prevention of which the use of approved chemical preservatives such as sulphur dioxide or benzoic acid is imperative. Refrigeration and cold preservation with sulphur dioxide are reputed to favour the maintenance

of vitamin content, whilst heat processing, unless strictly and carefully carried out together with the exclusion of oxygen, is inimical to the maintenance of vitamin C potency.

(4) Preservation in a sterile condition by heat processing with or without the addition of sugar. Two classes of material are produced, viz., "canned fruit" and "jam" (inclusive of preserves, marmalade and jelly). Containers are either cans or vessels of glass or earthenware, cans being cheapest but subject to corrosion unless enamelled, and glass allowing discolouration of the contents by light. In the canning of fruit, the tin can is both processing pan and container and is heated to a determined temperature for a regulated period whilst hermetically sealed, and the contents out of contact with air. The can is then rapidly cooled.

The fruit filled into the can is choice—selected uniform in both size and maturity, and the medium in which it is generally cooked is a refined sugar syrup varying in strength with the requirements of the fruit and its acid content. Fruit is also cooked in its own juice and known as pulp, this is mostly a trade intermediary product for later canning or conversion into jam.

Many chemical changes take place when fruit and sugar are boiled to jam; flavours are in some cases completely altered, sugars are inverted, insoluble starches and pectins brought into solution, etc., but not all these changes are beneficial; and the art of the fruit preserver consists as much in avoiding certain reactions as in promoting and bringing about others. For instance, he wants a good set, a bright natural colour, a rich flavour and aroma and a certain degree of sugar inversion. To insure the former, he must boil much and concentrate well, but overboiling or prolonged boiling will, amongst other things, reduce jellying capacity, caramelise sugars, boil off flavour and aroma, and darken and dull the natural colour.

Jam is not a chemical compound of fruit and sugar, but rather something in the nature of a stiff semi-solid dispersion of fruit in a saturated aqueous solution of sugar.

The pound calories of the canned fruit and syrup are in the neighbourhood of 300, and those of the jam about 1,500, this comparison indicating the relative food value and emphasising the point that jam is a rich concentrated food.

The average composition of jam is roughly: Sugars 70%, fruit acids 1%, mineral salts, flavours, etc., 1%, insoluble (woody fibre, etc.) 1%—5%, water 23%—27%; about half the "sugars" consists of "invert" and from 86% to 96% of the item is comprised of added sugar, depending on whether the sugar content of the fruit is high or low.

By-Products.—The fruit supplied for preserving and processing may lose from 5% to 50% of its weight after peeling,

coring, seeding, trimming and removing damaged, defective, or otherwise unsuitable material. The discards could be utilised in a crude form as stock feed or manure, but often provide the basis of a large by-products industry. The Hawaiian pineapple industry presses and refines discarded skins, cores and offcuts to give sugar syrup for canning fruit and pure citric acid, whilst the shredded and dried residues are a valuable stock feed. The Californian Fruit Growers' Exchange produces from citrus "culls" and surpluses a high-grade pectin, juices, concentrates and citrus oils. In South Africa the grape products industry provides raisins, grape-juice, wine, vinegar and tartaric acid. Extensive apple-growing countries press out the juice and convert it into cider, the residual marc or pomace being a rich source of pectin. In Durban, a citrus products factory produces citrus pectin, citrus oils and stock feed from its discards.

The proteolytic enzymes, bromelin and papain, are also obtained from the pineapple and the pawpaw respectively. In these By-Products industries, success is largely dependent upon mass production and the spread of the high cost of machinery and plant.

Research.

In the development and production of new and better varieties of fruit, having special inherent characteristics such as improved colour and flavour, prolonged cropping season, elimination of undesirable constituents such as seeds, stones, woody fibre, etc., resistance to drought, disease, insect infestation, etc., great strides are being made all over the world. This also applies to processing preservation, packing, storage, transport, etc., and no fruit producing country, much less one young in years like South Africa, can afford to be complacent and rest on its laurels.

Effective work is, however, being done in the Union in these directions, notably by the Western Province Fruit Research Institute at Stellenbosch, and wider developments under the aegis of the C.S.I.R. can confidently be anticipated.

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AGRICULTURAL SYSTEMS AND THE HEALTH OF CROPS

BY

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Presidential Address to Section "C" of the South African Association for the Advancement of Science.

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In the early days of the human race, when man first passed from the stage wherein the fruits of the earth were collected in a naturally occurring state, to the stage in which deliberate cultivation began, he produced a change in the environment not only of the selected species, but also of the numerous organisms which in the wild state existed and multiplied upon them.

The presence of fungi on leaves and in the internal stem tissues of higher plants has been found in fossil remains of lower Carboniferous and Permian ages, and it is almost certain that Neolithic man with his cultivated patch would encounter to some extent the depredations of his chosen food plants by their natural enemies. By the very act of encouraging the growth of those selected types, an unnatural set of conditions would be created wherein the balance attained in nature between different species and their enemies would be altered, and in which the conditions for the parasite would improve as the numbers of their host plant increased. In addition, parasitic organisms would be actually propagated by means of infected seeds or cuttings, and as the primitive cultivator moved from one area to another, he would no doubt be responsible for a certain amount of dissemination of contaminated propagating material.

Evidence points to the earliest attempts at cultivation being made in regions where the natural vegetation was bush or forest. The preparation of the site for cropping consisted, as it still does to-day among primitive peoples, of cutting down the vegetation, perhaps after ring-barking and drying, and then burning.

The soil became enriched with wood ash, and was planted, no doubt after rain. After about three years of cropping, the patch became unproductive, and a move was made to another site.

In the Maya type of agriculture as practised to-day, and which is probably a relic of those early days, a similar system

is followed, with the exception that a fallow is introduced. Here the cleared site is cropped for one year only, after which it lies dormant for from two to six years before once again being planted. Gradually, however, the soil becomes less productive and cultivation must cease.

It is interesting to enquire into the possible causes of the deterioration in cropping capacity which forced the primitive cultivator to seek fresh land for his crops. Such a phenomenon is usually simply referred to as soil exhaustion, implying the removal of the elements necessary for plant growth; closer examination of the problem, however, suggests that other factors may also have played an important part in determining the longevity of the cultivated patch as a food producing area.

The sequence of events following the burning of natural tropical vegetation has been the subject of special investigation in Malaya in connection with the preparation of sites for planting rubber, and the arguments advanced for and against such a practice as burning afford us some clues as to its value or otherwise.

If considered only from the plant food aspect, it would appear that burning the vegetation on the site to be cultivated gives rise to an increased amount of mineral constituents in the soil, which are immediately available to crops but which become readily depleted with successive crops; the loss of humus from the soil due to the fire has been found to be small, but of course there is considerable loss due to the lost organic matter of the burned vegetation.

From the point of view, now, of crop sanitation it would be reasonable to suppose that the complete destruction of the forest debris would eliminate the danger of pests and diseases spreading from decaying vegetation into the new plantation; this however has been found not to be the case, at least with root disease. It has been shown that less disease is present in young rubber after planting an uncleared area than after planting a cleared area, and further that in plantations less disease is present when a cover of weeds is allowed to grow, and still less where secondary forest growth is allowed. The practice of burning appears to accelerate the spread of root fungi among subsequently planted trees, and a rapid increase of root disease has been noted between the second and third year after burning off the natural vegetation.

It is not intended to press the analogy too closely between the above observations and the chance of their obtaining under primitive agriculture, but they do lend colour to the view that depletion of soil nutrients in itself may not account completely for crop failure under such a sysem. The biological status of the environment, especially with regard to the occurrence and possible increase of soil inhabiting fungi must be regarded also

as a factor which militated against the continued cultivation of crops in these patches of burned vegetation.

It may be assumed then that disease and pests of crops made their appearance in the very early stages of the domestication of plants by man. It may equally well be assumed — in fact it is known — that primitive man was completely ignorant of the real cause of any loss he may have experienced due to such agencies.

Further, his selection of types of food plant would be made without consideration being given to their ability to resist parasitic attack, except probably in such cases where serious loss was encountered and unconscious selection would be made by the simple process of elimination of the diseased types. (The deliberate selection of disease resistant types did not follow until the true nature of disease was known.)

Although not cognisant of the cause of plant disease, the early agricultural writers were fully acquainted with their devastating effects upon crops, and references to their occurrence date from the earliest times.

Thus in Deuteronomy we read of the blasting and mildewing of corn being meted out as a punishment for disobeying the Mosaic law; Aristotle in 350 B.C. referred to rust in wheat and the Roman feast of the Rubigalia was an early attempt to minimise the loss caused probably by the same disease. Pliny was familiar with plant diseases, while Virgil refers to the plagues which visited the corn, and to the death of crops.

Writing in Sanskrit in 1300 B.C., the Great Saint Parasara gives instructions whereby the diseases and pests of paddy may be removed by the quaint method of writing a hymn on the leaves of the screw-pine and then tying these leaves on some of the ears of the rice plant.

Such early references to plant diseases and pests point to the antiquity of man's appreciation of the fact that his cultivated crops were subject to influences which, even if their true cause was not realised, interfered with their yielding capacity.

From those early days agricultural systems have evolved to meet the various requirements of soil, climate and the economic needs of various peoples; the fallow has been introduced and the system of crop rotation practised; but with the spread of agriculture the enemies of the crop have attained a world-wide significance, entailing the maintenance in all advanced countries of organisations aimed at minimising the effect of these parasites.

The object I have in mind in the present discussion is to examine the various forms of husbandry practised, and to attempt to evaluate their significance as means in themselves

of maintaining the incidence of pests and diseases at as low a level as is possible.

At the outset, it must be appreciated that, irrespective of the type of agriculture adopted, the very fact that cultivated plants are withdrawn from their natural habitat, and grown in communities consisting of one species only, creates a situation whereby their natural enemies are afforded a greater abundance of their host plant than in the natural state; even in cases where cultivated land supports a mixture of species such as in mixed pasture, the frequency of the types grown is still great In addition, the selection of types for cultivation had in the earlier days been directed largely towards characters other than disease resistance. It is only within late years that serious attempts to combine high yield with greater disease resistance have been made, such a step having been made possible by the special knowledge possessed by the plant breeder and the plant pathologist.

An analysis of the relationship between health of crops and the manner in which they are grown, indeed, in most cases brings us to this fundamental fact, that for economic reasons cultivation consists of growing in solid masses one particular type of plant, thus ensuring a copious supply of food for its own parasitic organisms; and this applies whether the system itself is one of the continuous cropping of one species, or whether it consists of a husbandry of alternating crops.

These two agricultural systems — rotation and monoculture — are worthy of closer examination, as they represent two extreme methods of cropping, and indeed it has been due to a comparison of the health of the crops grown under these extremes that the present discussion has originated.

The system of husbandry which consists of the alternation of crops of a diverse nature, with perhaps a fallow included, has as one basis of its structure the conception that the same species, if grown for too long a period in the same soil, will deteriorate in cropping capacity due in part to the increase of parasitic organisms which find in that plant species a suitable host. By simply rotating that species with another, which is unsuitable for the parasite, the latter is prevented from increasing unduly.

Crop rotation appears on the surface to offer a simple method of disease and pest control, and is widely practised, not for this reason alone, however, but because in addition it provides for better utilization of the resources of the soil and has certain economic advantages, i.e., regarding labour. To be effectual, however, accurate information must be available of the life histories of the pests and diseases of the crops involved, as well as the resistance of all of the latter towards the parasites.

Where a disease, for example, is caused by a soil inhabiting organism which is specialised in its requirements towards one type of crop, and at the same time is short lived in the absence of its host, a short rotation will provide a satisfactory means of control, always provided that in the rotation is not included another alternative host plant, and that susceptible weeds are kept in check.

Where, however, a disease is capable of lying dormant in the soil for many years, a rotation which is longer than the period of viability of the parasite may be found to be unsuitable on economic grounds, and other means of attacking the problem will require to be found.

Another complicating factor is the ability of some organisms to persist as saprophytes in the absence of a host plant and the measure of their control by a rotation will depend upon the nature and length of such saprophytic existence.

Unless these factors are known it is conceivable that in altering from one form of husbandry to another, conditions might be provided for the continued existence of a disease, and the introduction of a rotation prove valueless as a control measure.

As examples of the relationship between crop health and rotation we may cite some of the cereal diseases. The take-all disease caused by *Ophiobolus graminis* is short lived as a saprophyte, and a short-period rotation, even in some cases of one year only, will keep the numbers of the pathogen in the soil at a sufficiently low level to warrant successful cultivation on this short term basis. Again, the resting spores of most cereal smuts are short lived, so short, in fact, that rotation is unnecessary; where, however, it is practised, a one-year period without the host plant is sufficient. On the other hand, cereal foot rot, caused by *Fusarium culmorum,* owing to its greater ability to survive in the soil or organic material, is not eliminated by the growing of non-susceptible crops, and hence crop rotation fails to secure the measure of control attained against take-all.

With the potato, wilt due to *Verticillium albo-atrum* can be controlled by a three-year rotation, while scab, due to *Actinomyces scabies,* requires a relatively longer period, owing to the greater length of time this fungus can exist as a saprophyte.

With wart disease, caused by *Synchytrium endobioticum,* resting spores of such longevity are produced that no rotation alone will ensure the cultivation of healthy potato crops; a rest of ten years has been found insufficient to eliminate this disease from the soil. Other fungi producing spores of long survival periods are the club root disease of crucifers, *Plasmodiophora brassicae,* which has been known to survive up to seven years, pea wilt, due to *Euphanomyces euteiches,* for six years, and the cabbage yellows, *Fusarium conglutinans,* for at least eleven

years. The incidence of Granville wilt on tobacco has been found to be unaffected by crop rotation.

Apart from the relationship between the persistence of diseases in the soil and the success of the rotational system, is the nature of the other crops introduced into the system.

Evidence is being accumulated that secretions from plant root systems exert an influence upon the microbiological status of the soil, and that one species may have a depressing effect upon the growth of some micro-organisms not exerted by another species. In addition, the incorporation in the soil of organic matter derived from one species of plant may reduce the amount of a particular fungus not affected by the incorporation of the remains of another plant. Thus it has been found that by mixing soy bean plants with soil and subsequently planting with maize, foot rot due to species of *Pythium, Helminthosporium* and *Fusarium* could be reduced; if, however, red clover was substituted for soy beans, no such control was experienced. Similarily, Ontario foot rot of strawberries was found to be controlled by rotating this crop with soy beans, but not with red clover.

Again, wilt of pigeon pea due to *Fusarium vasinfectum* has been found to be better controlled after a crop of tobacco than after a crop of linseed or a fallow.

The influence of previous crops on the health of the following one has also been noted in one case of the blind-seed disease of rye grass, where the seed from the same healthy source was used to sow several fields. In one field, which followed a four-year ley, the rye grass showed an incidence of the disease up to 55 per cent., whereas in other fields, which had been under arable crops for three or four years, the disease occurred very slightly or not at all.

Sufficient examples have perhaps been quoted to illustrate the complexity of the problem, but mainly to show that a rotation based on insufficient knowledge or appreciation of the factors involved might defeat the very end for which it was devised, and lead to an unbalanced agricultural system having no effect on the health of the crops it was intended to protect.

Mention has already been made of the introduction of a fallow into the cropping system whereby the land is allowed to lie uncropped for a period. The benefits of this practice have been recognised from very early days, and to-day fallows of various lengths of time are introduced into systems both of rotational cropping and of monoculture. The benefit of a fallow is undoubted, especially as a control against many species of weeds, and also with certain soil types to allow weathering to proceed and so improve the tilth for the next crop, while in dry-farming systems they have as their object the storing up of one season's rainfall.

An additional benefit, however, appears to be that in some cases a certain measure of disease and pest control is obtained. It has been suggested that the exposure of the soil to the sun's rays, especially in the warmer countries, has the effect of partially sterilising the soil, and is one reason for the benefits to be derived from the inclusion of this practice in some Indian and Egyptian types of agriculture. Under such conditions, also, the disappearance of crop residues in the soil is hastened, thus lowering the amount of material available for the survival of certain types of micro-organisms.

Cases have been recorded, however, in which the fallowing of land has not been followed by the disappearance of disease; indeed, an increase has been observed under some circumstances. Thus it has been shown that the take-all disease in infected wheat stubble persisted longer in a fallow than under a crop, the more rapid disappearance under the latter condition being attributed to competition between the take-all fungus and the roots of the succeeding crop of trefoil, mustard or oats for the limited supply of soil nitrogen.

Again, browning root rot of cereals caused by *Pythium sp.* has been found to be worse after a fallow than after a wheat crop; this phenomenon was attributed to an increase in the nitrogen-phosphate ratio in the soil under fallow, thus lowering the resistance of wheat plants to this type of root rot.

A practice, therefore, such as fallowing, with its benefits in some agricultural systems, cannot be applied in a haphazard manner any more than can crop rotation, in the expectation that an improvement in the health of the crops must necessarily follow.

In distinct contrast, now, to the culture of crops in a system of rotation, is the continuous growing of one crop on the same land for an indefinite period.

With many crops this method has led to very serious consequences, inducing a condition popularly referred to as soil sickness. This condition can usually be attributed to the accumulation of some specific organism parasitic towards the crop plant, for example clover sickness due to the fungus *Sclerotinia trifoliorum* or to the eelworm *Tylenchus dipsaci*, flax sickness due to *Fusarium lini*, or potato scab due to *Actinomyces scabies*.

On the other hand, some crops can be successfully cultivated under a system of monoculture, provided some other measures are available for the control of diseases when the necessity arises. The example may be quoted of continuous barley growing in some parts of England, provided this crop is undersown with trefoil; the latter is attributed with the capability of keeping the take-all disease, to which barley is susceptible, at a low

level by competing with it for nitrogen in late summer and autumn; whereas barley alone sown continuously is attacked in the second or third year.

Again, cotton is grown continuously in Antigua under irrigation provided methods are followed of controlling root rot due to *Phymatotrichum omnivorum*. One of the best examples of successful continuous cropping, however, is that which is most familiar to myself, viz., the cultivation of sugarcane. This crop is of special interest from the point of view of our discussion, since the system of sugarcane monoculture adopted in most countries is not universally followed; there are some regions in which this crop is grown as one of a series of rotated crops. In Java, sugarcane is only permitted to be grown for one year in any field by growers who rent the land, after which it must by law revert to the owner, who cultivates a food crop, e.g., rice. This type of husbandry has arisen out of the system of land tenure practised and the density of population which demands that prime importance be placed on the cultivation of food crops. Thus the alternation of sugarcane here with other crops is due to economic factors rather than plant pathological ones.

Another sugarcane growing area where a rotation appears to be beneficial is in the reclaimed alkaline tracts in the Punjab where sugarcane is alternated with rice, a legume, and wheat or cotton; here, now, the rotation appears to be the solution of a specialised plant nutritional problem. In New South Wales sugarcane is rotated with maize, sorghum and a cereal; this, however, is in the dairy farming area, where it is more important as a fodder than as a sugar-producing crop, and such a rotation provides feed all the year round, thus solving a problem for the milk producer.

The above quoted examples are those of true rotation; in those countries in which the monoculture of sugarcane is practised, it is often found, nevertheless, that between successive cycles of this crop a green manuring crop is grown. Thus in Fiji a legume, cowpea or Mauritius bean, or even a grass or weed crop, is taken, but no alternation of crop and animal husbandry is practised. In Egypt, Natal and other countries a legume is planted between sugarcane crops, not with the object of feeding animals but as a green manure crop for ploughing under. This practice not only acts a a method of weed control, improves the tilth of the soil and increases the store of nitrogen, but to a limited extent exerts the same influence on the soil microbiological population as a more complex rotation, and it has been the experience of many sugarcane growing countries over a long period that under such a system, with the introduction of this bastard fallow at frequent intervals, the continuous cropping of this plant can be carried out successfully.

To those accustomed to mixed cropping, the continuous culture of one crop appears on the surface to be unsound, and while this is probably the case for sugarcane in some countries where the whole economic structure of a community is based on the marketing of one commodity, in others where this same economic factor does not apply, the continuous cropping of sugarcane is admittedly sound. Moreover, the practice of ratooning or the taking of successive crops from one original planting, is an economic necessity in countries of high labour costs, where the profit to the grower is made on the ratoon crops, but not on the plant crop, i.e., that derived from the original planting.

The important question pertinent to our discussion is that with sugarcane, continuous cropping does not, in suitable soils, lead to a reduction in soil fertility, nor to an accumulation in the soil of disease organisms to the point at which cultivation of this crop is no longer possible. In Cuba some fields have been in continuous production of sugarcane for about 100 years, while experience in Hawaii, the West Indies, Natal and elsewhere goes to show that, provided good agricultural methods are adopted, soil productivity can be maintained and perhaps even increased under such a system.

It is not intended to present an argument in favour of the exclusion of other types of husbandry in an exclusively sugarcane growing area; other features may arise which suggest the possibility of introducing, perhaps for economic reasons, an alternative to sugarcane, such as some form of animal husbandry.

The introduction of high yielding varieties of sugarcane has made possible the production of sugar, under a system of controlled markets, on a smaller acreage, leaving land unused for this crop available for others. As has been pointed out previously, however, the introduction of alternative crops may present new problems to the plant pathologist. Thus in Natal at the present time, the introduction in some districts of the sugarcane belt, of dairying, cattle fattening or pig rearing has created a demand for fodder grasses, and among those which have been found suitable and are increasing in popularity are species of *Setaria;* unfortunately this genus contains some species which are susceptible to one of the major sugarcane diseases, mosaic, caused by an insect transmitted virus, and two species of this grass already exist in Natal and are sources of infection for the sugarcane crop. Symptoms identical with this disease have recently been found on one of the cultivated grasses, *S. splendida,* and, although it would be premature to assess the importance of this finding, it obviously creates a situation which cannot be overlooked by the plant pathologist.

In this instance we find the disease factor becoming complicated by an attempt to introduce a type of agriculture which would appear more rational than does single cropping. It is also apparent from acquaintance with sugarcane cultivation that it suffers no more from pests and diseases than does any other crop cultivated as part of a rotation; major diseases can readily be controlled by the use of resistant or immune varieties, a method which has met with spectacular success in several sugarcane growing countries. It might be expected that an accumulation of disease organisms in the soil would arise, and while this to a certain extent is true, it is known again that different varieties have different susceptibilities towards these organisms, and varieties can be grown that are less affected by such soil factors.

This short survey of different types of agriculture leads us to acknowledge that, in considering the health of the crops involved, no hard and fast rule can be drawn relating the system of agriculture to the control of pests and diseases; no one system is essentially good nor is another essentially bad in itself. Moreover, a change from one type to another sets in motion a series of events the consequence of which are difficult to assess at the time of the change-over.

So far, we have confined our attention to the broader aspects of crop husbandry systems. If we examine the matter more closely, now, we find that within each system variations of practice can be devised which serve to promote crop health. For example, certain agricultural operations can be carried out in such a manner or at such a time that the crop is at a stage of its growth when it offers most resistance to invasion by a parasite when the latter is most active. Thus, times of sowing can be planned to enable the crop to evade attack; with cotton, a measure of control over boll diseases may be obtained by sowing so as to permit vegetative growth during the wetter season and ripening of the crop during the drier months. With sugar beet in California, it has been found that early planting, resulting in bigger plants when the leaf hopper which transmits the curly top disease invades the field, is a practical method of preventing severe loss. On the other hand, a late sowing of winter wheat is less severely attacked by *Helminthosporium* than is early sown winter wheat. Again, the same crop is less prone to attack by bunt, caused by *Tilletia tritici* and *T. laevis*, if sown in midseason than if sown either early or late.

Diseases may also be escaped by the use of varieties which mature during a season when a particular parasite is least active. Thus black rust of wheat, due to *Puccinia graminis*, in East Africa may be evaded by the cultivation of early maturing varieties. With sugarcane, it has been found in Hawaii that the eye spot disease, caused by *Helminthosporium sacchari*, may be

lessened in severity by planning a programme of irrigation and application of nitrogenous fertilizer which aims at the utilization of the maximum available nitrogen during the summer months, and to lessen the rate of growth during the winter, eye spot, months.

The method of planting some crops on ridges, as opposed to flat land, has been credited with securing a certain amount of control over diseases favoured by a high moisture content of the soil, such, for example, as wilt caused by *Fusarium annuum* in chillies, or black leg in sugar beet, due to several fungi.

Again, there are those plant diseases to which a crop is more subject when it is in a state of faulty nutrition, or in an unsuitable environment, such as can be caused by unhygienic or otherwise unsuitable soil conditions, or by attempting cultivation in an area to which the crop is not suited.

A faulty nutritional condition may be one either of impoverishment, or it may be due to the excess of one or other ingredient for normal growth.

The susceptibility of plants towards certain debility diseases, which attack them when in an impoverished state, is, however, by no means universal; if the environmental conditions best suited to a parasitic organism are also those that favour the plant, then the latter can be attacked when vigorously growing; in fact, a more flourishing plant simply means a more copious supply of food material. For example, the lime disease caused by *Rosellinia* in the West Indies often kills the best trees, owing to this same set of circumstances.

The fact that some plant diseases are accentuated when the host is in a debilitated condition has given rise, however, to the unfortunate impression that all crop ailments can be overcome by cultural methods which have as their objective the production of a vigorously growing plant. Thus at present there is a school of thought which attributes plant diseases to the use of inorganic fertilizers, and claims that their cure lies in the use alone of decomposed crop residues manufactured by various methods of composting. The sweeping claims made by some of more ardent supporters of this view are untenable to the serious student, but their views, if regarded as a challenge to the more orthodox plant pathologist, bring to the fore the necessity for more knowledge on the relationship in the soil between organic matter and plant disease. Without doubt some diseases are controlled, at least under some conditions, by the application of organic matter, for example potato scab, flax wilt, take-all of wheat and cotton root rot.

On the other hand, some diseases have been found to be favoured by the application of organic matter to the soil, such as tea root rot, bunt and flag smut of wheat, *Verticillium* wilt of tomato, and *Pythium* root rot of sugarcane.

Further, although in the manufacture of compost by the decomposition of plant debris in heaps sufficient heat is generated to destroy the mycelium and spores of most fungi, the fact must be borne in mind that some organisms produce resting spores of an extremely resistant nature, towards which the temperatures produced might not be lethal; such a compost would hence serve as a source of inoculation for infecting ground to which it was applied.

The spread of *Sclerotium rolfsii* by such means has been shown to have occurred in Malayan gardens.

The argument that the introduction of mineral fertilizers has been accompanied by an increase in plant disease is likewise untenable; indeed few plant pathologists would agree that loss of crop due to disease is greater now than before. The number of diseases recorded and named has increased owing to the fact that the science of phytopathology exists, the functions of which is to perform this service; due, however, to the same science the control of disease is achieved with greater efficiency. The greatest crop failures in history occurred before the use of mineral plant foods became widely adopted — such as the potato blight which caused famine resulting in the death of millions from starvation, the vine mildew which caused distress among French growers, the failure of wheat crops through bunt, the disastrous coffee rust in Ceylon, and the epidemics of red rot which threatened the sugar industry in more than one country.

These are but a few of the most outstanding examples of plant diseases which ravaged crops in the days when the application of minerals to the soil was a negligible factor in production.

Once again, now, we see, as in the case of the relation between the system of cropping and plant health, that a modification of agricultural operations within the system while in some cases resulting in greater freedom from disease, in others brings about no such desirable consequences. Other methods of disease control require to be sought to ensure the successful cultivation of crops; the aid of the plant breeder to maintain a supply of resistant types, and of the chemist to provide chemicals of therapeutic value, are among the foremost requirements of modern methods of attack upon the spoilers of our crops.

We come back to the beginning of our discussion; man, by the very fact that he has extracted crop plants from their natural environment and grown them in fields or plantations, thus ensuring a copious food supply for the multiplication of pests and diseases, has created an unbalanced environment wherein the damage done by destructive organisms becomes more accentuated than in a natural community of plant life.

We find moreover that by substituting one type of agriculture for another fresh problems arise for those whose business it is to safeguard crop health; this aspect of husbandry has been brought to the fore in Britain during recent years, when a ploughing up programme has reduced the acreage of grassland and increased that under arable crop, with a resulting upset in the balance of the insect population, which will not stabilise itself again till stability is attained in the proportion of arable farming to grassland.

In the United States changes in the relative proportion of different crops have introduced new problems and intensified existing ones; while the introduction of methods devised to prevent soil erosion such as strip cropping, the maintenance of a soil cover and the planting of trees are creating environments favourable for some crop pests.

In South Africa we are witnessing at present a change in outlook towards the soil; the change over from old methods towards new conservation methods of farming is under way.

Perhaps it would be well, then, if we realised at the start that our difficulties will not be finished when the retention of the soil has been accomplished. A new complexity will be introduced into our cropping systems; some practices devised to prevent the loss of soil may even be contrary to the requirements of crop hygiene—the battle for the soil will be accompanied by new problems in crop health. The evolution of any new systems therefore demands that each step be watched for any such untoward developments; and the final structure that is built requires all branches of agricultural science for its builders if the relation that exists between climate, soil, crop and parasite, is to be maintained in that finely adjusted state wherein the loss due to the parasite is kept at the lowest possible level.

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THE POSSIBLE FIELD OF ANATOMICAL RESEARCH IN SOUTH AFRICA.

BY

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Presidential Address to Section "D" of the South African Association for the Advancement of Science.

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It is, I believe, decidedly unusual for a specialist in Human Anatomy to preside over the section of our Association which embraces all the branches of Animal Biology. The President of a Section most often reviews in his address some of the latest developments in his special field of Science. I should not be surprised if there are many, even among biologists, who imagine that in Anatomy there are no recent advances to be thus surveyed, that the study of bodily structure, both in Man and animals, is a sterile or exhausted field.

Such an opinion is plausible when we remember the long history of descriptive anatomy, compared with those of many other branches of biology. The modern period in the history of descriptive Human Anatomy is considered to begin with the "De Humani Corporis Fabrica" of Andreas Vesalius, published in 1543. Animal Anatomy has had an equally long period of development, and definitely assumed its modern shape in the work of Edward Tyson at the end of the seventeenth century. It is not surprising, then, that a remark which I made in 1943 on the significance of that year as the quadricentenary of the "Fabrica" of Vesalius evoked the comment: "Surely in four hundred years everything worth knowing about the human body has been discovered?" My reply was that, on the contrary, we are still finding out how much we do not know. After reflecting on the subject for three years, I still consider this statement essentially true, both for human and animal structure. Consequently, I have ventured to devote my address to considering some of the conspicuous gaps in our knowledge. More particularly, I wish to indicate some directions in which fruitful research can be undertaken in South Africa.

Before embarking on this survey, we may spend a moment in considering the status of Anatomy among the biological sciences. It may legitimately be claimed that the study of Anatomy is the essential foundation for all other branches of

animal biology. That the descriptive, classificatory, and historical aspects of biology, such as Systematic Zoology, Palaeontology, and Physical Anthropology, depend entirely upon an accurate knowledge of structure is unquestioned. It might be thought equally evident that the sciences dealing with normal and abnormal function, Physiology, Pathology and the Clinical branches of human and veterinary Medicine, are equally dependent on such knowledge. This dependence, however, is sometimes ignored or minimised by the specialists in these fields.

In a recent paper Straus and Sprague (1944) have discussed certain physiological studies which appeared to contradict the fundamental morphological concept of a specific relationship between muscle groups and their motor nerve supply. These conclusions were based entirely upon evidence from experimental physiology; the authors who enunciated them had not studied the morphology and actions of the muscles in their experimental animals, but made the erroneous assumption that they were identical with those of Man. By combining morphological studies with physiological experimentation, Straus and Sprague had no difficulty in demonstrating the fallacies underlying the revolutionary inferences of the previous investigators. Extreme though this example may be, it emphasises the wisdom of the remarks made by Professor C. G. S. de Villiers in his Presidential Address to this Association in 1940:

> " . . . we should insist that physiologists should have a thorough grounding in anatomy and particularly in comparative anatomy . . . Chemical or reflex or responsal physiology will never oust anatomy, as some people delude themselves into believing, since, to choose the very simplest words, no one can understand what an animal *does* before he knows how an animal *is*."

The delusion that studies in functional or "living" biology can be pursued with a very sketchy anatomical background has been fostered by the misconception that Anatomy deals only with "dead" structure, that it describes a static, non-functioning, and therefore artificial condition of the animal body. On the contrary, the true anatomist is fully aware that animal structure belongs to a living, moving, reproducing and evolving organism. Given this realisation, the study of structure becomes as vigorously alive as any other branch of biology. To quote from Professor de Villiers' address:

> "The criticism of some physiologists that comparative anatomists restrict themselves to form, to the exclusion or neglect of function, is a mere illusion. . . . In reality the morphologist could not leave function out of consideration even if he were to try."

Yet so firmly rooted in the minds of some biologists is the conception of Anatomy as essentially a non-functional science that immediately the anatomist takes function into consideration he is liable to be accused of trespassing upon the domain of the physiologist. It is time to reaffirm that anatomy has always a functional aspect quite distinct from physiology. Indeed Anatomy may legitimately be defined as the science of animal structure studied in relation to function.

For the present-day anatomist this functional dynamic approach to his study is facilitated by the development of new techniques for examining structure in the living body, such as cinematography, radiology and improved intra-vitam methods in microscopy. In our enthusiasm for these new methods we tend to forget that they can only yield their full value when they are combined with the old well-tried techniques which we have at our disposal. It is because the new techniques do not replace but supplement the old that the range of our powers of investigation is increased. Similarly, experimental methods for studying living structure have been developed with enormous benefit to the subject. The striking successes thus achieved sometimes obscure the vast possibilities which straightforward anatomical observation still possesses. In devising our relatively crude experiments on animal structure and growth, we are inclined to forget that every animal type in its adaptation to its way of life constitutes a far more complex and delicate experiment carried out in Nature. The results of these elaborate natural experiments can be ascertained by the classic methods of comparative anatomy.

Let us now consider the present state of our knowledge. I have said that Anatomy has to provide the structural data needed by many diverse branches of animal biology, taxonomic, evolutionary, genetic, functional and clinical. When, in the light of these demands, we assess what we know even of Man, the most extensively studied of all animal types, we find it to be still gravely deficient. For other animals our structural information is even more limited. While this proposition is generally true, it applies with particular force to the human and animal types indigenous to Southern Africa. Our detailed anatomical knowledge of these types is far more limited than that which exists for most regions of the Northern Hemisphere, if not also for the other large land areas of the Southern Hemisphere.

The fauna of Southern Africa includes many types of the greatest interest for every aspect of biology. Some of its components, like the Hyracoidea (dassies), are forms whose ancestors have been native to Africa over a very long period of time; others are by comparison recent immigrants. Among these are many remarkable refugee types from other parts of the world. Some of these are primitive types driven out of their original

homeland by the competition of more specialised forms; others are extremely specialised types which were compelled by changing environmental conditions to migrate in search of a more congenial habitat. Besides these isolated refugee types there are the large groups of successfully specialised forms which have established themselves in this region as triumphant invaders.

All of these animal types, both primitive and specialised, deserve much more detailed anatomical study than most of them have yet received. In the nervous system alone, a diversity of long-term experiments has been carried out in Nature among our South African animals. These include the modifications accompanying the reduction and loss of limbs in snakes and some lizards, the changes in the brain associated with the specialised sensory mechanism in bats, the extraordinary elaboration of the olfactory mechanism in the Elephant Shrews, and the suppression of the visual mechanism in blind lizards, Golden Moles and Rodent Moles, or its elaboration in many nocturnal forms. Besides these gross variations in neural architecture, the much more subtle differences between closely related forms of differing habits are still to be analysed.

Related to the nervous system and at the same time presenting in their own right a wide field for structural investigation, are the modifications of the skeleton, joints and musculature associated with differences in posture and locomotor habits. The recent work of Howell (1944) on "Speed in Animals", shows the wide range of anatomical information required to elucidate this one particular aspect of locomotor specialisation. At the same time Howell's survey brings clearly to light the gaps and discrepancies in our present knowledge even in this restricted field of inquiry. The South African fauna includes an unrivalled array of diverse postural and locomotor specialisations as yet very little exploited by anatomists.

While certain outstanding structural problems in particular animal types force themselves on our notice in this way, there is in fact no aspect of structure in any South African species which would not in some way repay close study. The types chosen for study need not be rare or difficult to obtain. In the paper by Straus and Sprague, to which I have already referred, it has been shown that remarkable gaps exist in current anatomical descriptions even of the domestic cat.

To the structural problems with which our living fauna confronts the anatomist must be added those presented by our fossil faunas, both the unique reptilian fauna of the Karroo deposits and the less well-known, but increasingly important, Tertiary and Quarternary mammalian faunas. Study of these fossil types may provide wholly new light on the problems of structure and function in existing forms. At the same time,

the fossils raise new questions which can be answered by returning to a more detailed consideration of living types.

The study of the Karroo reptiles, as Dr. L. D. Boonstra reminded us in his Presidential Address to this Section in 1939, has now been carried on for just over a hundred years. It has been repeatedly urged that this study should now assume a morphological rather than a taxonomic bias. That is to say, now that the main outlines of evolution within the Karroo fauna are known, emphasis should be placed upon unravelling the detailed structure of the known types, rather than on searching for new species, genera, or even families. The unrivalled wealth of specimens from the Karroo deposits offers employment to many investigators, but it would be a pity if they all considered it their primary object to add more names to the already long list of recorded species. In many of these named species, only the most salient diagnostic characters have as yet been described. It would well repay one group of comparative anatomists to concentrate on the detailed anatomical study of these known forms, leaving others to specialise in taxonomy. An example of this approach is the recent work of Olson (1944) on these Karroo fossils. As is to be expected at this early stage, this work provokes more questions than it answers. Still it demonstrates how morphological analysis can fill in the details of evolutionary history.

Work of this type cannot be completed without a renewed and elaborated study of structure and development in living forms, both reptiles and primitive mammals. This will be particularly the case as the uncertain dividing line between reptiles and mammals is approached. Of especial significance to South African comparative anatomists is the conception now widely held that the placental mammals did not arise from the marsupials, but that both diverged from a pre-placental stock which was not strictly marsupial. This implies that the structure and development of the most primitive placentals afford evidence regarding the earliest stages in mammalian evolution at least as valid as that furnished by marsupials. While South Africa has no marsupials, it possesses some placental types which under cover of a veneer of specialisation have retained many extremely primitive features. Two of these fundamentally primitive groups are the Golden Moles and the Elephant Shrews. The latter group is at last receiving the detailed study that it deserves; some of the remarkable discoveries which have resulted were touched upon by Professor C. J. van der Horst in his Presidential Address to this Section last year.

In recent years South African palaeontologists have become increasingly aware of the significance of the Tertiary and Quarternary mammalian faunas of this country, which provided the animal environment of early man and his precursors. Since

the description of the fossil Australopithecus by Professor Dart in 1925, we have come to realise that South Africa was formerly inhabited by a group of extinct primates, the Australopithecinae, which may justifiably be considered proto-human. The recent memoir by Broom and Schepers (1946) shows how remarkably these fossils conform to the character of a pre-human ancestor of Man, and how strong is the probability that Man arose from among the members of this group. The deposits in which these pre-human relics and those of early Man occur have a patchy local distribution, so that the accompanying fossils provide our best evidence for determining their relative age. At the same time these South African fossil faunas throw much light on the evolution of various mammalian groups, such as the wart-hogs among Ungulates and the baboons among Primates.

We are at present gravely handicapped in studying these fossil mammalian faunas through lacking detailed anatomical knowledge of many living forms. The palaeontologist must rely upon osteological and dental characters whose range of variation in living types is at present largely unknown. Thus Dr. Broom pointed out in 1940 that the remarkable fossil monkeys discovered in South Africa cannot be properly classified because the existing types are distinguished mainly by external features useless to the palaeontologist. We have to recognise that this is true of the majority of animal groups. The work of Shaw (1939) on the growth changes and variations of the molar teeth in living wart-hogs forms a model of the type of study which is essential for any real advance in our knowledge of the relationship between the fossil and the recent mammalian faunas of South Africa.

Inadequate knowledge of the range of variation in living mammals leads to two opposite errors in palaeontology. On the one hand it has repeatedly happened that supposedly new species have been created which are in reality well within the range of variation of forms already known. In this way a false impression of the number of extinct species in a fossil fauna is produced. Conversely, species which are really distinct may be confused through too liberal an estimation of the range of individual variation, so that the range in time of a species either living or extinct may be exaggerated.

This difficulty of establishing justifiable limits of variation particularly besets our interpretation of proto-human and human fossils. Some anatomists have tried to minimise the significance of the humanoid characters displayed by our Australopithecine group of fossils, because comparable features are found sporadically in individual specimens among the existing manlike apes. However, no anthropoid ape shows anything comparable with the assemblage of humanoid characters which each of the Australopithecine fossils reveals. The work of Broom

and Schepers (1946) on these specimens leaves very little for other anatomists to do in this field until additional finds of this group are made.

Anatomists were at first loath to admit that any human fossil could be even specifically distinct from *Homo sapiens,* no matter how it might differ from the average of modern human beings. Later the pendulum swung to the other extreme, so that not merely species, but genera of fossil Man were being created in almost a light-hearted fashion. The tendency has now been unmistakably reversed, and the limits of generic and specific variability in Man are being much more carefully considered.

The main difficulties in interpreting the human fossils from South Africa in terms of this new viewpoint arise from the very small number of specimens available for discussion. It is salutary to remember that only half-a-dozen crania have been described which can plausibly be assigned to the Middle Stone Age, and that only two, the Broken Hill and Florisbad skulls, have any claims to a greater antiquity. Real progress in our understanding of these fossils depends far more on new specimens being discovered than on continued discussion of the few already available. There can be no question that many specimens still await discovery. In the past such finds have resulted far more often from accident than from systematic exploration. The evident and increasing awareness of the significance of these remains shown by the educated public encourages us to expect that in the future casual discoveries will have an even better chance of being preserved. Facilities for systematic exploration are also being steadily expanded. We may confidently anticipate therefore that future South African anatomists will have many more fossil human types at their disposal. These in turn will raise new anatomical problems for investigation in the modern types of Man.

Turning to living Man, my answer to the question asked three years ago may now be elaborated. After four hundred years we have amassed a generalised knowledge of the structure of Man, which has been adequate to the demands made on it in the past by other branches of human biology. This knowledge is nevertheless far from being complete to the last detail. More than once in recent years the clinical sciences have required information which anatomists were not yet able to supply. Our knowledge of the variations in the anatomy of individual men, however, remains far less complete, and the available data are very imperfectly co-ordinated. It is with regard to the variations which distinguish human groups rather than individuals that information is most conspicuously lacking.

Living human beings have come to be broadly classified into a number of physical types distinguished by external characters

of the body. The anthropological study of these varieties of modern Man has clearly reached a critical stage in its development. Many authorities indeed dismiss as all but worthless most of the work carried out in this field. There is no question that the fundamental concepts of this study have been drastically modified by developments in other branches of biology and particularly in genetics (Ashley Montague, 1941). At the same time, a much more critical attitude towards the data of the subject has come to be adopted, notably in the emphasis on statistical methods.

Both in the methods and in the aims of this study, however, the process of revision is sometimes carried to an extreme which appears hardly justified. In the hands of some workers the statistical treatment of measurements has so far ousted the analysis of structure that Physical Anthropology is in danger of becoming a branch of mathematics and not of biology. The mathematical anthropologist needs to be reminded that Physical Anthropology is essentially a branch of descriptive anatomy. Measurements are only significant in so far as they give concrete expression to observable physical differences. The real need in this study is not for a more elaborate metrical technique but for a more refined descriptive analysis.

The data of Physical Anthropology undoubtedly need to be drastically re-interpreted in the light of modern genetics; the older anthropological theories of race may well have been inadequate or ill-conceived. But this revision need not be carried, as is sometimes the case, to the length of practically denying that physical type has any biological significance. This negative attitude is largely a reaction to the manner in which the concept of race has been misused to bolster political theories of racial superiority or inferiority. Nevertheless, it is surely equally unscientific to minimise the significance of human physical types. Even if these types should prove to intergrade with each other either in space or in time, they constitute an essential element in the picture of Man as he exists to-day. The systematic analysis of these physical types is therefore a prime necessity in human biology. Such an analysis can be pursued without in the least implying that any particular type is either biologically or socially superior or inferior to another.

The external characters by which every human individual can be identified as to physical type are consistently present and are transmitted by inheritance. Whatever genetic mechanisms are responsible for these characters, their operation can hardly be limited to the exterior of the body; the anatomist may expect to find differences widely distributed throughout its structure. These can hardly fail in every case to exert an appreciable influence on function. Immediately they assume a practical bearing upon the clinical sciences. The recognition

of such a structural basis for functional differences between human physical types is therefore no longer a theoretical but an extremely practical contribution to knowledge, since it is agreed that normal function is best preserved or restored by maintaining or re-establishing normal structure.

The practical need to record the anatomy not merely of Man but of human physical types is steadily becoming more and more urgent. Some anatomists of an older generation did investigate the structure of these types, often in the more or less formulated belief that they would prove to differ in their stage of structural evolution. The results in most cases appeared disappointing. This we can now see to be due to the very imperfect conceptions of human history by which these results were interpreted; the answers were unhelpful because the questions were wrongly framed. Human structural variations do in fact throw valuable light upon the course of human evolution, corroborating and in some respects amplifying the evidence of palaeontology. Thus a comparative study of the foot musculature in different human types and in other Primates has led me to conclusions regarding Man's relationship to the Primates which agree remarkably with those formulated by Dr. Broom from examination of the teeth in human, pre-human, and simian fossils. Nevertheless, the structural analysis of human types now derives its most powerful impetus not from a theoretical interest in their origins and relationships, but from directly practical observations.

From this standpoint our knowledge of the African varieties of Man lags far behind that which has been amassed concerning Man in other parts of the world. A compilation ambitiously entitled " The Biology of the Negro " which appeared some years ago (Lewis, 1942) affords very striking evidence of this. The anatomical data in that work are very limited, and moreover are mostly based upon observations of the Negro in America and not in Africa. Experience has taught us that conclusions based upon this transplanted and appreciably modified Negro group cannot be unreservedly applied to any African Negro peoples. This survey is open to the criticism of having been based principally upon work published in America, so that a number of contributions made in South Africa and elsewhere escaped notice. Even when these are added, however, it remains evident that we know far too little of the anatomy of the Negro in Africa.

We have in fact become aware of many anatomical features in which the South African Negro appears to differ from the European, but without being able in most cases to define these differences. The study of the skeleton and joints has yielded a series of as yet unco-ordinated facts concerning the foot, knee, hip, and vertebral column. These need to be verified, amplified,

and welded into one conception of the mechanism of posture and locomotion in the South African Negro. Muscular variation, which in the past has been studied chiefly for the light which it throws upon morphology and phylogeny, must also now be considered in its relation to body mechanics. The detailed pattern of vascular distribution and its variations needs to be worked out in the South African Negro as in other types of Man. Perhaps more significant than any of these, both the gross and the microscopic anatomy of the brain in the South African Negro are largely unexplored. Inquiry into these aspects of structure is clearly a pre-requisite for the comparative study of physical and mental aptitudes and performance in African and other types of Man. It ought to be emphasised that in the comparative anatomy of human types, more perhaps than in any other field of study, valuable results can only be obtained by painstaking observations over a very long period of time.

I trust that this partial review has at least served to indicate something of the unexplored territory which the anatomist in South Africa has before him. This does not in the least imply that South African workers have up to the present been slothful in tackling the problems that confront them. The labourers in this field have simply been too few for the harvest. Moreover, research has been for most workers a luxury to be enjoyed in rare moments of leisure from more urgent duties. Nevertheless, under these cramping conditions, an impressive volume of sound and essential work has been accomplished in this country. Within the last few years, the facilities for investigation have been in many respects vastly improved; correspondingly the number of workers and the output of contributions to knowledge have steadily increased. Despite this we are still only at the beginning.

We are now being constantly assured that in the immediate future the facilities for research will be still further increased. Both upon those who will direct and those who will carry out research under these new conditions, I would urge that studies in animal structure can be confidently expected to yield results second to none both in fundamental significance and in practical application.

In conclusion I should like to say something of the part which this Association can play in furthering these studies. I believe that in the future as in the past one of its most valuable contributions will be the encouragement which it gives to young research workers. The value of this Association to the young worker was recognised by the British Association when it founded our junior medal to commemorate its visit to this country in 1929. In no field of research has this award been earned so frequently as in that of animal and human structure. Apart from the stimulus of competition for this medal, the

young worker profits both in having our Journal as a vehicle of publication and in establishing contacts at our annual meetings with older colleagues from different centres. In the process of reconstruction during the next few years, the manner in which our Association can best discharge its function of advancing Science in South Africa will inevitably come under review. Because I have the strongest appreciation of the benefits which I as a young research worker received from the Association, I feel it my duty to urge that in the future these benefits should be even more freely available to the young worker than in the past. I can think of no way in which this Association can more effectively promote the Advancement of Science, just as I can imagine no field of research more full of promise for the future than that of animal and human structure.

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SOME BIOLOGICAL ASPECTS OF PREHISTORY

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Presidential Address to Section "E" of the South African Association for the Advancement of Science.

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I am deeply conscious of the compliment and high honour which attaches to being President of that Section which devotes itself to the study of Archaeology, Primitive Technology and Physical Anthropology. These three subjects all make their respective contributions to that relatively new humanistic science which is called prehistory, and their cultivation is specially important in South Africa, where the field which they cover is so enormous. Nowhere else in the world is the record of what is called the Old Stone Age so continuous and so extensive as it has been shown to be in our river terraces and cave floors. In no other country has the historic period impinged so extensively on the pre- and proto-historic, with so many attendant racial problems and all the associated interweaving of primitive and advanced cultures.

It is small wonder then that subjects, which might otherwise have been regarded as academic, have gripped the attention of South Africans in all walks of life, for it is a notable fact that in these sciences amateurs have made valuable contributions to the advancement of knowledge. It so happens also that our prehistory has an interest for mankind in general, so that our responsibility is thereby greatly increased. Unlike history, which is dominated for the most part by a national outlook, prehistory tells in a detached scientific manner the long story of man's past. The fact that scientists of all nations accept this as a common heritage augurs well for the possibility that future history may be written on a more universal note.

As a physical anthropologist I am naturally more interested in the human types which have made Southern Africa their abode during the long period of prehistoric time. In this connection I may say at once that the anatomical record is not nearly so complete and so continuous as the cultural one. It is, however, rich in representatives of the later phases and it extends back to the precultural period and presents us with some of the Dawn forms of actual human shapes. It is not my intention to discuss these latter South African Man-apes, the Australopithecinae. They have been ably described by Dart and Broom, and their position as pre-human links between the

anthropoid apes, such as the chimpanzee and the gorilla, and the earliest undoubted man, such as the Ape-men of Java and China, is now generally recognised.

After the Australopithecinae there is a considerable gap in the human pedigree in South Africa until we come to our modified Neanderthal types such as Rhodesian Man and Florisbad Man. The interval is well covered, however, on the cultural side, because the series of stone implements from the pre-Stellenbosch pebble-cultures right up to our Middle Stone Age (including Mousterian types) is very complete. The physical nature of the man who made the stone hand-axe has, however, not yet been determined in any part of the world, and that is not surprising when one considers how much more perishable bone, unless fossilised, is than stone. It would appear that Stellenbosch Man and his corresponding Abbevillian type in Europe were, like the Australian aboriginal, not cave-dwellers at least until the very latest phase of their existence. This greatly minimises our chances of finding him, but the fact that he did enter on the bottom floor of our oldest caves does make the excavation of the deepest levels a matter of great importance.

Early Man in Java.

For the earliest steps in human evolution one has to turn, not North to those great centres of human cultural advances, but East to that other fringe of the Old World, the Island of Java. Here during the last fifty years, and especially during the last few years, there has been discovered a remarkable sequence of human forms. The latest of these finds is the mandible of a giant hominid, which Dr. von Koenigswald discovered in 1941 and called Meganthropus. Its gigantic proportions, surpassing in massiveness all previous finds of human or hominid jaws, lends realism to the fairy tales of giants and their pigmy killers. Incidentally the teeth of a still more gigantic type of Ape-man or Man-ape, Gigantopithecus, have recently been found in South China.

The next branch of the phylogenetic tree found in Java is the famous Pithecanthropus erectus, the erect Ape-man discovered by Dubois in 1890. Owing to its incompleteness this specimen presented a somewhat baffling problem until in 1926 a whole series of first cousins of this type began to be discovered near Peking in China. Recently also a more complete specimen of the original type has been found in Java, and the ranks of giant forms have been swelled by a more massive specimen, called by Weidenreich Pithecanthropus robustus. In none of the finds in Java, however, is the cultural association good, and if it had not been for the evidences of fire, implements and cannibalism from China, we might still have been denying full human status to these low types.

The third human step is represented in Java by Homo Soloensis, a primitive Neanderthaloid type intermediate in status between Pithecanthropus and Neanderthal Man. The fourth step is represented there by Wadjak Man. This skull is comparable in appearance to the Gibraltar and Galilean skulls, both of which are variants of the Neanderthal type, so that we can say that this discovery takes us quite up to that particular level of human status. Wadjak Man also links up with Homo Sapiens in the shape of the Australian aboriginal of which he is the Javanese prototype.

I have thus briefly sketched the stages through which man has passed from pre- to sapient man in the course of long ages and in one relatively small part of the world. There is no reason to suppose, however, that this perfect Darwinian picture of the evolution of man was limited to Java. This island has indeed the credit for having produced a type of sapient man, but it has proved to be a "sterile" type and the end of a human line. A series of recent finds in Australia points to the fact that it was a proto-Australian such as has been evolved in Java that reached that Island Continent ages ago, and we know that during the long period of his residence there he has only succeeded in becoming the primitive present-day aboriginal.

It would appear therefore that other australoids with greater potentialities must have evolved in other parts of the world in order to take the sapient man to the higher levels which it has undoubtedly reached in other races. Rhodesian Man, Cape Flats Man and elements in the Koranna suggest an Australoid line in Southern Africa. There is also a great belt of Australoid types, fossil and recent, linking Europe through India with Indonesia. This type also reached North America, where it constitutes a basic element in the Red Indian pedigree. These Australoids had the great advantage over the Australian aboriginal in that, with at least as good a genetic background as a starting point, they did not continue as a pure and unevolving strain but mingled with other breeds of men.

Juvenile and Senile Races.

Of these other human experiments quite the most remarkable are those "living fossils", the Bushmen, and the still more extraordinary paedomorphic or juvenile pre-Bushman types. The Hottentot and his Boskopoid ancestor also belong to this special group of sapient man. Anatomically they present a striking antithesis to the senile Australoid type. In all the preceding steps of human evolution there had been a gradual slowing down of the rate at which the individual members matured so that they reached adult life in a form more like the infants of the ancestral types. It was in this way that pigmy forms arose, and these, relative to their size, have bigger brains

than their ancestors, so that they mark an advance in human evolution. Here in South Africa there are juvenile forms with an exaggerated size of head which seem to have taken too big a jump in this direction, and, like the Australian, they are the end of a line and are verging towards extinction. But this type made its contribution to human advancement, not here in South Africa where they flourished for ages as a relatively pure strain, but by the fresh leaven which this type of man introduced into the human pedigree. The blood-group affinities between the Bushman and the Eskimo, and the numerous special anatomical links between the Hottentot and his Boskopoid ancestors with Cromagnon Man of Europe and with Mongolian Man can only be explained on the assumption that there was at one time a North-South belt with this genetic constitution. It was from different proportions of the widespread and variegated Australoid types blended with equally widespread and variegated big-headed types that most probably white, black, yellow and red men arose. The brown races may be, as Keith thinks, on the way to the above colour specialisations, or they may be later fusions on the fringes of great and long isolated pockets of white (European), Black (Negro), Black (Australian and Papuan), Yellow (Mongolian), and Red Indian men.

Thus far I have been outlining broadly the origin of the peoples of the world as it has been revealed by fossil finds. The evidence is for the most part anatomical, and the criteria of advancement have been for the most part increase in brain size and complexity. There has at the same time been a gradual reduction in the size of the jaws and a concomitant "humanising" of the teeth. Except for minor adjustments of the bones of the skeleton to suit the more erect posture which man has gradually assumed, the changes in the skeleton have not been marked in the last half million years. It can be taken that the one thing which has mattered in human evolution has been that instrument with which man has controlled and still controls his destiny, namely, the human brain and mind. Whilst we are fortunate in having in the endocranial casts of fossil skulls almost exact replicas of the brains which were lodged within them, it is a matter for gratification that we so often have at the same time the implements which that brain and mind had conceived and forged.

The Biological Background of Primitive Technology.

With a good deal of appropriateness the subject of Primitive Technology has been given independent standing within the Section over which I have the honour to preside. This is no doubt because, whilst it embraces a knowledge of the various techniques of stone-knapping used in the various Stone Ages, it continues its survey of human inventiveness through primitive peoples right up to modern times. But this subject is not just

the collection of examples of successive cultural efforts in stone and the exhibition in Museums of pottery and of primitive methods of weaving or of smelting metals. It is the history of science taken right back to the time when man first began to use his skill to control and fashion his environment for his own ends.

In order to understand the problem with which man was first faced, and, as I hope to show later, is still faced, we have to draw a clear distinction between the biological and physical aspects of Nature. It is generally accepted that the physical world came into existence first of all as a fiery molten mass of inorganic matter integrated with the other planets and rotating in its own orbit round the sun. From this physical arrangement sprang day and night, the different seasons, the local climates and those strange long cycles of alternate Ice and Tropical Ages. I must not omit that necessary satellite the Moon, which, by causing the tidal movements, presented later life with the alternatives of living on wet or dry land.

This was the sterile scene on and from which the transcendent force of Life was born. The superlative quality of this living force lies in the fact that it is a constructive molecular arrangement of the atoms C, H, O, N, S, P, which enables it to incorporate the mechanical, chemical, thermal and electrical energies of the physical world. The mechanisms by which living organisms move and carry on their internal activities are those of engines and chemical laboratories. They have in addition special qualities of their own. They can grow, that is to say they can convert and add other ingredients to their own chemical constitution, and they can reproduce themselves. The supreme quality of living matter is that it has been imbued from the start with mind. That is to say, it can react to external stimuli and thus adjust itself to external conditions. In short, with the gift of the life force to the world was given the power to control it. The whole story of evolution is simply an expansion with examples of the above principles of growth and of the interrelationship of mind and matter.

Modern research has shown that life can exist in the form of the ultraminute and paracrystalline virus, and it is probable that life first took shape in an analogous molecular form intermediate between the inorganic and the organic. Theoretical as the foregoing conception is with regard to the origin of life, my own researches have shown that, in the reverse direction, when organised living tissue disintegrates, it breaks up into vital molecular units.

For ages living things were chiefly concerned in building the coral reefs and in laying down the beds of chalk and coal. For other millions of years the changing story of fossil development was being written by the Reptiles on the floors of lakes which

later cataclysms and upheavals reared into our present mountains.

Until man appeared the various types of animals and plants fed upon one another in a cyclical manner. Plants borrowed mineral salts, their chief ingredients apart from water, from the inorganic world. The animals which fed on plants breathed back to them carbon dioxide whilst they were alive, and when dead returned their tissues to fertilise the soil. Animal life also preyed upon itself and in this way the powerful biological forces of growth and reproduction were held in check and the balance of nature was maintained. This competition for food and the natural disinclination to be fed upon compelled the different animals to adapt themselves for the struggle and to assume offensive and defensive mechanisms for survival purposes. Pennicillin, for example, which we are apt to regard as some magic kept by Pandora in her box for the occasion of a World War, is nothing more than the natural chemical defence which the moulds have evolved to protect themselves from their low rivals, the bacteria. It was, as Darwin postulated, a case of the survival of the fittest and best adapted for the possible ways of life.

It should be noted, however, that the adjustment was all made from within, by modifications of their own anatomy. The carnivora specialised in tooth and claw, the horse in fleetness of foot. The former practised cunning, the latter caution and a quick retreat. Any deviation in the individual that was not in keeping with the existing conditions was ruthlessly exterminated, any failure of the group to respond anatomically to a changing environment meant extinction. The whole process was mechanical, and biology abounds with examples of instinctive behaviour and architectural adjustment to the existing surroundings.

Development of the Projective Mind.

The Primates, however, began to introduce a new idea in their relationship to other animals and to the physical world in general. Living as they did for the most part in trees, they could afford to discard many of the internal defensive measures that were so necessary to animals living on the ground. Thus they could dispense almost entirely with the important sense of smell which had so far dominated animal life. This set the brain free to enlarge in motor, sensory, visual and auditory directions. To the monkey it was much more important to grasp and get the feel of the swinging branches than merely to get a good clutch-hold with claws. Fruit and nuts require picking and there is a saving of effort in being able to tell by its weight whether a nut is worth cracking or not. Progression in trees is, moreover, usually up and down so that the foundation was laid for the erect attitude.

It was left to man himself to take the next step and divorce his anatomy almost completely from having to respond to external conditions. When the climate became cold he need not grow fur, but could make a fur coat from the pelts of other animals. For offensive and defensive purposes he could use sticks and stones, but he could not and he cannot even to-day afford to dispense with all the brain power and inventiveness that he can muster up for the everyday emergencies of the human life.

I am satisfied that man has been a tool-maker throughout his existence, that is to say that he has been continuously in search of external means of supplementing his own internal weaknesses. There is some evidence that forms by no means human can on occasion become tool-users. In this connection the extraordinary behaviour of a little South American monkey at the Groot Schuur Zoo is worth recording. This little creature amused visitors for years by the human-like manner in which it held the nut with one hand and cracked it open with a stone in the other hand. I need not enlarge on the refinement of visual, tactile and motor judgment that is necessary for such an accomplishment. The baboons are reputed to throw stones from the krantzes and I have known a fellow in captivity who could throw gravel with some force, especially when one's back was turned.

Professor Dart considers that the fossil baboon skulls from Taungs show evidence of having been fractured ante-mortem by a blow from some weapon such as a stick or a stone, and for this he inculpates the Australopithecinae. I have a number of fossil baboon skulls from Taungs which support this contention. In the case of the Ape-man from Peking there is no doubt that he, in addition to his knowledge of fire, could make a crude form of implement and use this to crack open the crania of his compatriots for a cannibalistic meal of brains.

Progressive Techniques and Creativeness.

The long period of the Stone Ages shows a continuous development of the use of stone for offensive and defensive purposes. What is interesting about the implements he made is the skill with which he studied the grain of the stone in relationship to the special type of knapping in which he indulged. He also had a primitive knowledge of geology as is shown by the consistency with which he made use of a particular kind of stone, usually the best material available in the locality where he lived. A notable feature of stone implements is the persistence, during long periods of time and over wide areas of the world, of implements of the same type or fashion. It is impossible to account for this traditional standardisation of the techniques of the various cultures without postulating that the

makers had some ritualistic belief in the importance of such detail.

Nevertheless there must also have been heretics, discoverers, and inventors in those far-off days, and from period to period there is a jump from the crude to the more refined. Stone-axes gave way to points, which were no doubt hafted to form spears. The bow and arrow replace the sling and mark a great step forward in inventiveness. At a later date stones are given a polish and the precarious occupations of hunting and fishing for food are replaced by the more certain supplies provided by domesticating animals and growing crops. The inspanning of the ox and the horse were the first great labour-saving devices. The hunter no doubt had his leisure moments when he could indulge in the art of engraving in the open or in painting in his caves. The agriculturist, on the other hand, had to built a hut or house and found plenty of scope for his decorative sense in pottery and weaving. Metals also claimed his attention, first bronze and later iron, thus foreshadowing our great steel industries.

About this time the human mind projected itself externally in one of the most fruitful directions it has ever taken. Someone began to draw those symbols which stand for the sounds of words. Henceforth ideas about things could become detached from the mind in that great currency of truth and magic which we call writing. With this prehistory ends and history takes up the thread.

Some Lessons from Prehistory.

The study of history is justified for the guidance which comes from contemplating past successes and mistakes. It has the disadvantages, however, that it is dominated by social and political considerations and that it has been written for the most part with that fundamental human conceit which postulates for humanity some special dispensations and prescriptive favours. Prehistory, on the other hand, integrates mankind with the Universe and demonstrates the majestic steps by which, subject only to the known biological laws, humanity has arrived at its present anatomical and social status. It is a science which recognises the essential unity of mankind but which at the same time lends understanding to racial diversity. It stresses the importance of considering the various biological forces which are at work in the world, and points out in what directions their aggressive character, freed as it now is from many natural restraints, may sooner or late have to be controlled.

One of the most remarkable lessons which Prehistory has taught us is that humanity has been in occupation of a major area of the land surface of the world for about a million years

and that in spite of his physical and mental handicaps man has maintained a reasonable balance between himself and the natural world. Although for the greater part of that time man knew of one of the most destructive agencies, namely, fire, the primeval forests spread and receded with alternating climates, and flowers and shrubs evolved and blossomed in all their variegated splendour. The same is true of birds and other faunal inhabitants of the world.

I am not predicating any special interest on the part of the aboriginal inhabitants of the world in the preservation of their natural amenities. One exception must be made, however, in favour of our own and those other prehistoric artists who showed their regard for their faunal associations by engraving them on stone and at a later date by depicting them in colour on the walls of caves. It is more likely that human aggressiveness in the past was limited by lesser needs than those of the present and by the vastly inferior weapons with which it preyed upon nature.

Nor do I wish to suggest that there has been any deterioration in the human outlook of the historical period during which so much has been and is still being destroyed. My contention is that human nature, in virtue of its origin, is essentially the same as in the past, and that it is only the conditions of existence which have so vastly changed. It is the primitive predatory instincts of humanity and the dangerous tools which have been put into man's hands that have made necessary such legislation as we have for the protection of our birds, our mammals, our flora and our paintings.

Custom has blinded us to the extent to which our moral and legal codes are based, not on authority, but on the acceptance of the fact that there is a biological need for them. Fortunately our educational system and that of the English-speaking world recognises that there is an inherent aggressiveness in youth which requires discipline and that far more effective form of sublimation of force which is learnt on the field of sport.

Humanity has reached a stage, however, when it is not individual but mass biological aggressiveness that is threatening to get out of hand. If we may judge from the prehistoric state of affairs which the White man encountered in Australia and South Africa, the population of any area of the world must for the whole of that long period have been relatively sparse. We can understand how the food supply of a hunting people is more precarious than that of an agricultural community, but just how this kept the population static is not so clear. Excavations in some of our caves, notably the one at Oakhurst, have shown the heavy infantile mortality of the cave-dwellers. Darwin, when he visited Australia in 1836, noted the rapidity

with which the Aboriginals were disappearing, and attributed this to a large extent to the fatal effect on infant life of their wandering habits and precarious food-supply. He had also noted the warring instincts of these people and of the Maoris, whom he had already visited.

Population Trends in the "Newer" Parts of the World.

The continued decline of aboriginal peoples is rightly attributed to their abuse of alcohol and to the introduction of European diseases, against which the aboriginals had very little immunity. Even mild diseases like measles took a heavy toll, and in South Africa smallpox carried off whole tribes of Bushmen. What I have said above applies also to certain contacts with protohistoric civilisations, such as occurred between the White man and the Red Indian in North America, and to some extent to that between the European and the Maori in New Zealand. In this direction South Africa has a notable exception to her credit. The Bantu, in spite of the only slowly relenting political subjections to which all warlike peoples, if they are defeated, are liable to fall heirs, have for the most part waxed fat and multiplied. They have been fortunate in having been spared those suicidal freedoms which have destroyed so many other aborigines.

The following figures show the accessions to the white, black and coloured races which have been made during the last few hundred years in the newer countries of the world. They also show the relative increases of newcomers and aboriginals over a recent ten-year period.

Australia	1933.	1943.
Aborigines	60,000	40,000
Half-castes	19,467	25,197
Europeans	6,657,701	7,204,667
New Zealand	1926.	1936.
Maori	62,781	82,326
Europeans	1,344,469	1,491,484
United States of America	1930.	1940.
Indians	332,397	333,969
Negroes	11,891,143	12,865,518
Europeans	110,286,740	118,214,870
Union of South Africa	1936.	1946.
Bushmen	6,513	
Hottentots	86,474	
Cape Coloured	578,236	
Asiatics	219,691	
Bantus	6,596,689	
Europeans	2,003,857	

Some Implications of Modern Population Trends.

Over one hundred years ago Malthus propounded his famous theory to the effect that under modern conditions a disproportion could arise between the growing number of mouths and the amount of food that would be available to fill them. This is a perfectly natural and therefore a scientific proposition, but it has been generally ignored as being doctrinaire. We have already seen that it was the way in which nature balanced these two quantities which kept humanity for so long on a level keel. The question which we have now to consider is whether the removal of natural restraints, which is achieved by reducing the mortality, will or will not affect the future balance.

We know that large areas of the world are already overpopulated and suffer from periodic famines. A devastating war and an unusually extended drought have shown that regional and distributional scarcities, which had already begun to appear, can easily be converted into a total world shortage of biological products. It is a mistake, however, to attribute this entirely to the War, when we know that unbalanced food economies were fundamental causes of the War.

The time has come, therefore, when we must pay more attention to this ratio between the growth of populations and the available potentialities of food supply. Much has happened in relationship to both these quantities since Malthus wrote his famous essay. With regard to the former I have pointed out above the huge populations which in the interval have come to occupy the "vacant" expanses of the world, upon which many of Malthus' contemporary critics were relying for a limitless supply of those biological products we call bread and butter. Some of these countries cannot even balance their own food economies, and South Africa is already an importer of human food.

In the interval also we have seen the great biological experiment in Australia, where the rabbit with no natural enemies to restrain his animal aggressiveness threatened to deprive humanity of the food-supply of a whole continent. In South Africa over-stocking and soil erosion have seriously reduced the food-producing potential. On the credit side, since Malthus' time we have seen the great scientific advances in agriculture which have masked to a considerable extent the possibility of a shortage. These have enabled the heavily populated areas of the world to jog along, those in Europe supplementing the home-grown with importations by the grace of Barter, whilst the teeming sub-economic populations of Asia have tightened their belts and accepted famine and its consequences as the way of their particular world.

With regard to the first quantity, namely, the natural growth of populations, the total population of the world has certainly

not increased as fast as Malthus predicted that it would, because artificial restraints have been introduced, but on the whole there has been a formidable increment. The rate of increase, however, has been very differential, and in countries which practise Western civilisation the birth-rate is declining, whereas under other civilisations populations continue to grow rapidly. In European communities the birth-rate is now the sole determinant of population increase, because owing to medical and social advances mortality has been reduced to a more or less constant minimum. In most non-European communities, on the other hand, mortality is still high, but it is being gradually reduced and, unless the birth-rate falls concurrently, this must ultimately add to the difference in the rate of increase of White and Coloured races.

The tendency of Western civilisation to stabilise itself numerically is sometimes regarded as a sign of decadence, but it may equally well indicate progress in human adjustment. Hitherto the long reign of force has put a premium on numbers, and a price, usually a bargain one, has been put upon reproduction for economic reasons, which at times are equally aggressive. The discovery of atomic energy has shown that, in the realm of force, numbers may now be at a discount, and, in the world of economics, it is clear that the average dividend or standard of living in any community must depend on the numbers who share in its wealth.

Earlier in this address I pointed out that the essence of being human lay in the consistency with which man has turned his back on the animal way of life and relied on external agencies rather than exploit his anatomy for defensive or aggressive purposes. I then briefly indicated how he had successfully applied his skill to the making of a graduated series of implements and machines which have given him the mastery of almost everything but himself. It must therefore now be obvious that if he would approach that final goal he must recognise that in a fast contracting world in which the naturally restraining influences no longer operate, there is no virtue and some danger in unbalanced reproduction. The story of mankind shows plainly that it is not the number of bodies but the quality of the human mind and its standard of culture which matters in the long run.

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"CORRECTNESS" AND SOUTH AFRICAN ENGLISH

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The advantage of a subject that has anything to do with pronunciation, for an address, even to an audience with such diverse interests as this one has, is that everyone has opinions on pronunciation. A man's pronunciation is as individual as his person, and everyone is interested in and resents criticism of his person. We are so constituted that we defend anything that is ours with great obstinacy, but little reason, whether it is our person, our property or our pronunciation that is attacked. And on matters so personal as pronunciation we never admit defeat: linguistically, peace comes without victory. Yet few people without specialised knowledge would presume to take part in a scientific discussion of cosmic rays or the effects of vitamin C on the guinea pig pancreas; but it is astonishing how many people, with little or no qualification, not only to-day but throughout the history of English, have laid down the law about pronunciation. And, to take an unfair advantage of my audience, I have to record that it has been said — though not of course by me — that the legislation of those who laid down the law was "emphatic in exact proportion to their ignorance". (1)

This process of laying down the law goes on not only in South Africa and England but in every English-speaking country. In America Professor Kenyon, for example, makes the same complaint:

> "There are few subjects on which educated Americans are so ready to pass judgment and give advice on the basis of so little sound knowledge as the pronunciation of the English we use. Influenced by certain types of teaching in the schools, by the undiscriminating use of textbooks on grammar and rhetoric, by unintelligent use of the dictionary, by manuals of 'correct English', each with its favourite (and different) shibboleth, and, it would seem, by anybody or anything that has an air of cocksureness about it, we accept rules of pronunciation as authoritative without inquiry into either the validity of the rules or the fitness of their authors to promulgate them.
>
> "Some of the rules are well founded, no doubt; but many of them are quite without foundation in the usage of past or present. Some of them are purely traditional, formulated a century

or two ago on theoretical grounds by teachers and writers who had no adequate knowledge of the history or phonetics of English; and they have been reverently copied and taught by later writers and teachers without a knowledge of either their ultimate origin or their validity. Yet we not only accept many of these rules ourselves, but seek to impose them on others by criticizing their pronunciation when it differs from what we suppose correct." (2)

One suspects that in all countries and at all times there have been people who have taken it upon themselves to be guardians of standards of "correctness" and "purity of speech". Probably every tribe and, in days of larger families and smaller tribes, even every family had its own authority who kept an eye on local standards of speech, just as they did on other sorts of behaviour. And indeed even to-day there is usually someone in every family, often the mother. who sets out to maintain a respectable standard of speech among the children.

In France and Italy they established Academies to do the job for them. English-speaking peoples have never been fond of dictatorships, and have kept their linguistic independence at the expense of some uncertainty about what is "correct" and "incorrect". Speakers of English have been more subject therefore to the influence of individuals who have laid down the law, with or without good reason. And when it happened that one of the legislators was a man of as wide an influence as, say, Swift, in the eighteenth century, then the opinions of even one individual have had widespread and lasting effects, in spite of the fact that for many of his decrees there is little justification of any kind beyond personal likes and dislikes.

Indeed it is not realised generally enough that so many of the rules laid down concerning English grammar as well as pronunciation are in origin the expression merely of the likes and dislikes of individuals. There are, for instance, teachers in England, America and South Africa at least who still instruct their children to pronounce the vowels in unstressed syllables carefully, i.e., giving them a full vowel; there are teachers who tell their children to pronounce carefully an *h* wherever it is written; there are teachers who still tell their children that *got* is an "ugly word", and that they must not end sentences with prepositions. Professional linguists have known for long enough that speakers of Standard English regularly use reduced vowels in unstressed syllables and say [əbteInd] instead of [ɑbteInd], and drop the *h* in unstressed syllables, e.g., in "Give *h*im *h*is hat". They also know that for centuries it was customary to end sentences in English with prepositions, just as it was and still is in other Germanic languages, and that it was again the influence of an individual, Dryden, that was largely responsible for making the prohibition so general. But such facts are not sufficiently widely recognised. Most intelligent children wonder why *got* is "ugly", and some even ask their teachers why. The

poor teachers, who are only repeating what someone else has told them, have no good answer. If they offer any, it is that the *g* is an ugly sound, or maybe the *o*, though why they should be ugly in *got* but not, presumably, in *god* is a little difficult to understand.

Indeed it is difficult to understand how any sound can be either ugly or beautiful in itself. A sound, or combination of sounds, may arouse pleasant or unpleasant sensations in us, but only because of the things that we associate with the sounds. And a line of poetry may arouse pleasant or unpleasant sensations in us, but not because certain sounds are repeated in the line, but because of the associations called up by the words themselves. The repetition of certain sounds may also have its effect; but it will be to give, say, emphasis, or memorability, to the line, not beauty or ugliness.

To put it another way, our standards of judgment in what are generally called the arts — literature, music, art, architecture, drama, films — are subjective, personal and unscientific. In the main they are often little more than expressions of individual prejudices. We like what we like because we like it. And we dislike what we dislike because we are not used to it. If we are brought up on western music, we think oriental music peculiar. If we are brought up to admire classical architecture, we shall abhor "modern stuff". And if we are brought up on the English of England, we shall think the English of America, of South Africa and Australia peculiar, inferior, perhaps even ugly. Because I happened to be born and brought up mostly in England, I cannot help sharing this prejudice; but at least I recognise that it is a prejudice and that there is no scientific justification for my attitude.

One of the greatest contributions of science has been the discovery of accurate and objective standards of measurement. We can measure accurately amps but not accents, temperatures but not Tennysons; we can weigh accurately a pound avoirdupois but not a Pound, Ezra. Given a standard test, half a dozen scientists could be relied on to get the same result; given a standard author, half a dozen critics could be relied on to get half a dozen different results.

We may never achieve an objective literary standard of measurement, and it is probably highly desirable that we should not. We may never achieve an objective linguistic standard of measurement, though the science of phonetics at least makes it possible to establish one, without trying to "fix" the language permanently in one form, as some people in the eighteenth century wished to do. Haldane (3) has commented on the effects of scientific discoveries and pointed out that old attitudes *have* been readjusted; whereas an attitude of resignation at times of epidemics used to be considered a religious virtue, it has

now become a criminal offence not to have a child vaccinated. So the development of different varieties of English in America and the dominions must be admitted and recognised, and our old attitudes to language readjusted in the light of new evidence.

The fact is that our standards of judgment concerning language, especially in South Africa, are out of date and need to be re-examined. That is why I want to try to show first, historically but as briefly as I can, how some of our beliefs and prejudices about correctness in English have arisen.

Up to the fourteenth century in England men spoke and wrote whatever dialect they were born or accustomed to; and all dialects were equally respectable, though there were sometimes disparaging remarks by the user of one form of English about the form of English used somewhere else, as, e.g., in the famous comment in the translation of Higden's *Polychronicon* made by the Cornishman, John of Trevisa, who said "All the language of the Northumbrians, and especially at York, is so harsh, piercing, grating and formless that we southerners can scarcely understand it." See (4), (language modernised). You will notice that even this early judgment that the pronunciation of English at York is "harsh" and "grating" is a purely emotive one, and is based on no scientific ground. It means no more than that the author did not like the pronunciation of York because people in Cornwall did not talk like that and he was unused to it.

There were also comments on the growing diversity between the dialects, and it was clear that sooner or later one dialect would have to be recognised as a national standard. Everyone knows it was the London dialect that was ultimately adopted as a written standard, but the reasons why the London dialect was chosen are usually not emphasised sufficiently. If, for example, Japan had come out on top in this last world war, we should probably all have had to learn Japanese as an international administrative language, not because Japanese was necessarily a *better* language than any other, but because the speakers of Japanese had made themselves influential people. That is to say, the importance of a language or of a variety of a language depends not on the merits of the language as a means of expression or communication, but on the importance of the speakers of the language. So when a national literary standard of English was needed, the London dialect was chosen not because it was inherently a *better* form of English than any other, but because it was the language of the ruling classes.

Our modern standard English is in origin, then, not only a regional dialect — that of London — but also a class dialect, for it was not the dialect of the lower classes of London that became the ancestor of standard English, but that of the courtly,

cultured, educated upper classes, because the members of the upper classes were in every way the most *important* in the country. In other words, as soon as discrimination between the varieties of English was made, it was made on *social* grounds. And discrimination on social grounds has continued ever since. The modern Cockney pronunciation [gaIt] for *gate* is not inferior aesthetically or euphonically, but socially: it causes the speaker to be associated with the wrong social groups. Of course, those who are or wish to be regarded as Cockneys may and will go on saying [gaIt], which for them will be a pronunciation superior to other and, as they may seem to them, more snobbish and affected pronunciations.

But when once discrimination starts, the desire for "correctness" grows, for speech becomes a mark of class distinction. So, on the education of a nobleman's son, Sir Thomas Elyot in *The Gouernour* (1531) recommends that

> ". . . a noblemanes sonne in his infancie, haue with hym continually onely suche as may accustome hym by litle and litle to speake pure and elegant latin. Semblably the nourishes and other women aboute hym, if it be possible, to do the same; or, at the leste way that they speke none englisshe but that which is cleane, polite, perfectly and articulately pronounced, omittinge no lettre or sillable, as folisshe women oftentimes do of a wantonnesse, wherby diuers noble men and gentilmennes chyldren, (as I do at this daye knowe) haue attained a corrupte and foule pronuntiation." (5)

Puttenham advises courtly writers to take as their standard

> ". . . the vsual speach of the Court, and that of London and the shires lying about London with lx. myles, and not much aboue",

and he adds:

> ". . . there be gentlemen and others that speake but specially write as good Southerne as we of Middlesex or Surrey do, but not the common people of euery shire." (6)

And Lyly on the education of children says:

> "They are to be trained up in the language of their country to pronounce aptly and distinctly without stammering every word and syllable of their native speech, and to be kept from barbarous talk as the ship from the rocks." (7)

Henry Dowes, the tutor of Gregory Cromwell, reporting in a letter to "his right honorable maister Mr. Thomas Crumwell chief Secretary vnto the Kings Maiestie" on Gregory's education, mentions a certain Mr. Southwell

> "dailie heringe hime to reade sumwhatt in thenglishe tongue, and advertisenge hime of the naturell and true kynde of pronuntiacon thereof." (8)

There is no doubt about the class distinction.

There were in the sixteenth century at least two important standards, both social ones, that of the court and that of scholars; and there is occasionally amusing evidence that they

were not the same. For example, the pedant, Gabriel Harvey, is represented on meeting Queen Elizabeth as having

> ". . . quite renounst his naturall accents and gestures & wrested himself wholy to the Italian puntilios, speaking our homely Iland tongue strangely, and but ten daies before had entertained a schoole-master to teache him to pronounce it." (9)

Sir Philip Sidney, a courtier, on the one hand, thought the best English was that of the court; Mulcaster, a schoolmaster, on the other hand, thought that English needed to be reduced to grammatical rules so "that men maie know, when theie write or speak right". (10)

The difficulty was that in the eighteenth century when George I, a Hanoverian, who could not speak English, came to the throne, French became the language of the court. The example of courtly English speech was thus withdrawn, as Thomas Sheridan, father of the playwright and author of a pronouncing dictionary (1780) laments:

> "There was a time, and that at no distant period, which may be called the Augustan Age of England. I mean during the reign of Queen Anne, when English was the language spoken at Court; and when the same attention was paid to propriety of pronunciation, as that of French at the Court of Versailles. This produced a uniformity in that article in all the polite circles; and a gentleman or lady would have been as much ashamed of a wrong pronunciation then, as persons of a liberal education would now be of mis-spelling words. But on the accession of a foreign family to the throne, amid the many blessings conferred by that happy event, the English language suffered much by being banished the Court, to make room for the French. From that time the regard formerly paid to pronunciation has been gradually declining; so that now the greatest improprieties in that point are to be found among people of fashion." (11)

The loss of the court standard meant that the dictionary-makers, scholars, schoolmasters and grammarians had a clear field. As Dr. Johnson put it, it was impossible now to fix the pronunciation "after the example of the best company because they differ among themselves". (12) And it was Dr. Johnson perhaps who had the greatest influence; and as far as pronunciation was concerned his attitude was that "For pronunciation the best general rule is, to consider those the most elegant speakers who deviate least from the written words." (13) This attitude has indeed survived all too well down to the present day, even, or perhaps I should say, especially in America, as, for example, Mencken regretfully notes:

> "The influence of Samuel Johnson is thus still more or less potent in the American public schools, though Noah Webster was denouncing it so long ago as 1789." (14)

McKnight points out that, in America where cultivated language has often had to be learned from reading rather than social contact,

> "The influence of spelling appears in the distinctively American pronunciation of such words as *trait* and *schedule* and *lieutenant* . . ." (15)

And, we may add, especially in the American pronunciation of English names that have been borrowed, e.g., *Birmingham* [-'haem] and *Thames* [θ e:mz].

Since Johnson's day the general tendency in speech in England too has been towards a more formal literary standard. This tendency has been strengthened since the Education Act of 1880 which made elementary education compulsory. This Act has had the effect of making the lower-middle and working classes, who were previously uneducated, very conscious of the social importance of pronunciation, and so has made them uncertain of their standards of speech. It has increased the desire for "correctness", that is, for speech which will produce the right social effect, and for rules laying down clearly what is right and what is wrong, so that people will know where they are, and can at least be correct even if they never achieve elegance of expression. In language, as in other things, men prefer certainty to truth. The history of English during the last couple of centuries has in fact been the history of the acquisition by the majority of the speech of the minority of a higher social level; or, to put it in another way, it has been the history of the cultivation of a form of English notable for its grammatical correctness and general flatness of level: we have succeeded sometimes in avoiding inaccuracies, but at the loss of vitality.

Many of our ideas of correctness, especially in grammar as well as pronunciation, have been accepted, without much examination, from eighteenth century writers. And I want next to illustrate briefly the sort of people they were and their standards of judgment.

In 1770 Robert Baker published his *Reflections on the English Language*. He says that he had only six years of schooling, no Greek and only Latin enough to forget. But in any case self-assurance was more effective than education: the essential was to say what you had to say three times in a loud voice and with plenty of confidence. So he cheerfully rushes in, and says "There is no such word", or "This is not English"; and admits that he has

> "censured even our best penmen, when they have departed from what I conceive to be the idiom of the tongue, or where I have thought they violate grammar without necessity. To judge by the rule of *Ipse dixit* is the way to perpetuate error." (16)

Yet this is precisely the rule or standard by which he does judge most of the time.

It is interesting for the historian to note that some authorities in Afrikaans seem to show the same attitude towards their language as Robert Baker and others showed towards English. Only recently I came across an article that said "There is no such word in Afrikaans, no matter what the dictionaries say."

A criticism of Baker's book appeared in the *Monthly Review*, which, on the basis of " physician heal thyself ", picked him out for his own errors and said that Baker's use of *'t is* was " a barbarous contraction of *it is*". (17) In the Preface to his 1779 edition, called *Remarks on the English Language,* Baker replied " It may be so in general, but ... " (18), for no authority admitted himself in error. But Buchanan gives his, the opposite, opinion, and says "*It's* for *it is* is vulgar; *'t is* is used." (19). Here we have clearly a case of class distinction only. This laying down the law is obviously a matter of personal preferences. The standard of these grammarians is purely subjective, and the kind of language each describes is his own. In fact, these self-constituted, and often linguistically untrained, authorities of the eighteenth century spent much of their time saying " Yes, it is ", " No, it isn't ", and giving each other metaphorical raspberries. The rest of their time went in finding reasons to justify their personal prejudices. Indeed a vast amount of this, and much other literature too, is a matter of rationalisation.

These examples, quite typical of eighteenth century pronouncements on language, should be a warning to us. As long as people continue to talk as the eighteenth century writers did of " the idiom of the tongue " or " the genius of the language ", anyone can put up his own subjective standard and no one can prove him wrong. The odd thing about men's attitude to language is, as Leonard puts it, that

> " whoever dislikes a word, or discovers that someone else has disliked it, is not content merely with using a preferable expression himself; " (20)

he has to try to persuade other people to share his personal prejudice. Before one can decide questions of " correctness " in pronunciation one needs more than a firm faith in one's own pronunciation and a delight in criticising the pronunciation of those who differ.

What is needed in South Africa is first an open mind on problems of pronunciation. I have been trying to show the necessity for this by revealing that the old standards are based on social differences and personal prejudices. Then secondly we need a large-scale phonetic survey of the way in which English is spoken in South Africa by people of different parts, and of different classes, sexes and age-groups. I have been carrying on an investigation of South African English pronunciation on a small scale for some time, but a large-scale survey would take the lifetime of one man, and by the time he had collected all the necessary evidence and was ready to collate it, much of it would be out of date But if we had all the evidence available now, we could say a little more accurately what constituted an educated South African English accent, what pronunciations were undesirable because they suggested an inferior social group, and we should be able to instruct teachers more precisely

what standard to aim at in the schools. We might also be able to make recommendations about the pronunciation of place-names in South Africa.

A large-scale survey by the methods of linguistic geography would have other advantages too which I should like to try to explain briefly. Linguistic atlases have been produced in several countries in Europe, e.g., in Holland (21), Corsica (22), Germany (23), Italy and southern Switzerland (24). Work has been begun on one in the U.S.A., and the first volume appeared in 1939 (25). Interest in the modern dialects in Europe grew when it was realised that eighteenth century grammarians were wrong when they supposed that the literary and upper-class standard language was older than the other dialects, and when they believed that dialect speech forms had developed through the carelessness and ignorance of common people. When it was realised further that the modern dialects often preserved old forms of speech which had disappeared from the standard language, scholars began to produce dialect dictionaries, grammars and maps which showed the distribution of speech forms.

These three methods of dialect study should be applied to the study of English in South Africa. The first method, lexical, has already been attempted, though it is easy to add examples of South African English to the New English Dictionary. The second method, grammatical, has also been tried though not systematically: there have been only unco-ordinated comments on such things as "throw him with a stone", "afraid for" and "play by so-and-so's house". The third method, that of linguistic geography is, briefly, to discover with the help of a number of trained investigators, and then record on maps, the spread of variant pronunciations of key words and phrases.

The isoglosses, or lines drawn on the maps marking the limits of the spread of variant forms of pronunciation, mark lines of poor communication between groups, for whenever two groups are cut off from one another by geographical, political or class boundaries their speech will develop in different ways. So, for example, isoglosses show the spread of the cultural influence of the great coastal cities of Holland in the sixteenth and seventeenth centuries. The Ürdingen line, the isogloss marking the boundary between those who use the sound [k] and those who use [x] in German for the word for *I*, actually cuts the town of Kaldenhausen in half, people in the western half saying [ex] and those in the eastern half saying [ek]. And up to 1789 the western part of the town belonged to the Catholic Electorate of Cologne, and the eastern part to the Protestant County of Mörs. The isoglosses cutting east and west across France record the old division of the country between French and Provençal.

A beginning has also been made with linguistic geography in Afrikaans (26), and some interesting results may be expected as the spread of particular word-forms in South Africa is linked up with areas in Holland from which settlers came, and as the spread of forms in the northern part of the Union can be linked up with, say, the Eastern or Western Province as the starting point of the trekkers.

Linguistic geography, then, confirms history and often throws light on it by revealing social boundaries.

A full-scale investigation of this sort would help us to establish a clearly definable standard of cultured pronunciation for South Africa in place of the very vague " Standard English " of England which is almost undefinable. It has so baffled definition that it becomes customary to try to define it by negatives and say that Standard English was a sort of English that did not give away one's class or regional origin, though it seems very doubtful to me now whether any such sort of English ever existed. What most cultured people in England to-day do speak is a form of educated English modified by local pronunciations. And what cultured people in South Africa speak is also a form of educated English modified by local pronunciations. But we need to know precisely what those typically South African pronunciations are that are found in the speech of educated and cultured speakers of English in South Africa, and be able to describe them scientifically.

My own investigations have been limited so far, principally by lack of time and opportunity, to small areas of the Rand and the Cape, and mainly to children of school-going age. So it is impossible for me to generalise and draw any reliable conclusions yet. I can only guess that certain pronunciations are commoner in the Cape than in the Transvaal, some commoner on the Rand than at the Cape, and some commoner among certain age-groups and class-groups than others, and so on.* For example, it seems to me that the pronunciation of the English diphthong [aU] as in *house* is more commonly [aə] in English speakers in Cape Town than on the Rand, whereas the pronunciation [æu] is met more often on the Rand among English speakers than at the Cape in similar groups.

On the other hand, there are several pronunciations which are found frequently among educated speakers in the Cape *and* on the Rand. The following are some of the most common:

ə for the Received Stahdard English I as in swɔm for *swim*

əi	,,	eI	gəit	*gate*
-əi	,,	-I	dəi	*Sunday*
-i	,,	-I	ɛni	*any*
-oi	,,	-ɔI	boi	*boy*
y:	,,	u:	ty:	*too*

glottal stop before a word beginning with a vowel ?ɛni *any*

It was very interesting to find that evacuees from England at even the exclusive boys' and girls' schools on the Rand and at the Cape had acquired these characteristics of educated South African speech.

Those pronunciations which we come to find later by investigation are shared by cultured speakers of English form the basis of our South African Received Standard English. For there is a received standard South African speech already, a speech used and accepted by cultured speakers, and still a speech that is recognisably South African in pronunciation. And teachers will be wasting their time if they hope to reproduce the "Standard English" of England here.

The same problem has bothered America for some time and still causes trouble in some parts. Mencken has commented on the fate of youngsters who speak American but have to learn English at school, and said that what their professors try to teach is not their mother tongue at all, and that there are still many American pedagogues who believe

> "that the natural growth of the language is wild and wicked, and that it should be regulated according to rules formulated in England." They also "devote themselves to teaching a pronunciation that is quite foreign to the country." (27)

The Americans are outgrowing this attitude which only conservative American teachers try to uphold. So should we in South Africa.

But I want to emphasise again that, when I say that South African Received Standard English pronunciation is no better and no worse than Standard English in England or America or Australia or Canada or New Zealand, I refer to the pronunciation of cultured South African English speakers and not, as so many assumed when I spoke on the subject before (28), to an extreme pronunciation of the uneducated, which I believe too should be avoided, though it should be avoided for social and not aesthetic reasons.

The trouble is that newcomers from England assume that because some varieties, the extreme varieties, of South African speech are socially undesirable, all are bad. I was, I think justifiably, amused therefore at what I found when I tested two of my most violent critics. One was a teacher who stoutly upheld the value and importance of teaching "Standard English" pronunciation in South Africa, and she gave some time regularly to "correcting" the speech of children in her care. She herself, I found, had marked traces of her original Irish accent as well as several pronunciations characteristic of South African speech. The other, even though an Oxford graduate and come straight from the fount of linguistic purity, had also succumbed to South African influence enough to have adopted the glottal stop. It is in fact possible to identify the place of

origin of most members of staffs of English departments in our universities from their pronunciation. If local modifications of received educated speech are alright for them, why not for their students?

It is important psychologically, I think, to adjust ourselves to this new point of view in order to get rid of a sense of inferiority. The attitude of mind that regards *any* pronunciation that may be called South African as automatically inferior is all wrong. It is not a matter of lowering the standard of English used in South Africa; it is a matter of recognising and granting respectability to a standard that is already accepted in practice among cultured speakers.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII*,
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CYLINDRICAL HEAT FLOW INTO A TUNNEL

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Read 3rd July, 1946.

1. *Introduction.*

In problems concerning ventilation in deep level mines, the following idealised problem is of considerable importance. We are given a mass of homogeneous rock extending indefinitely in all directions, and an infinitely long straight tunnel of circular cross section of constant radius R. Initially the whole rock is at constant temperature u_0. At zero time the surface of the tunnel has its temperature quickly reduced to the temperature u_1, and is maintained at that constant temperature indefinitely. Heat then flows through the rock along radial stream lines drawn towards the axis of the tunnel. (See Fig. 1.) The problem is to calculate the rate of flow of heat through the surface into the tunnel at any subsequent time.

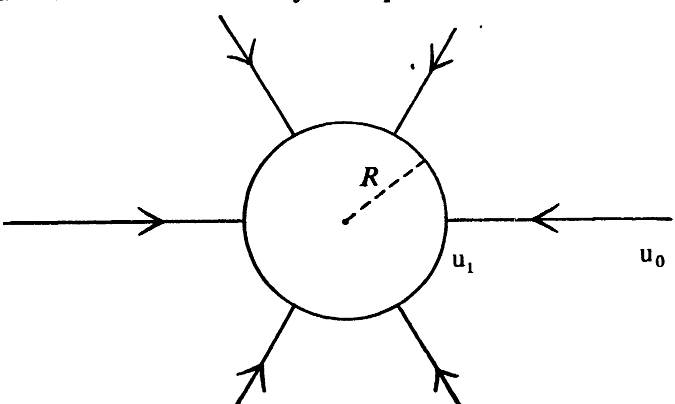

FIG. 1.

A fórmal solution of this problem has been given by several investigators such as Nicholson (1921), and Carslaw and Jaeger (1938). The work of putting this formal solution into the form of simple functions or of a numerical table suitable for practical use was started by Smith (1937), but was accomplished more successfully by Goch and Patterson (1940) in the Transvaal Chamber of Mines. The rate of heat flow into the tunnel per sq. cm. per sec. at any time t can be written as

$$\frac{k(u_0 - u_1)}{R} T \left[\frac{at}{R^2} \right] \qquad \text{.................................(1)}$$

where k is the thermal conductivity of the rock, and a is its diffusivity equal to conductivity divided by the product of specific heat and density. Numerical values of the function $T(\alpha)$ from $\alpha = 0.01$ to $\alpha = 1000$ were published by Goch and Patterson (1940). Their $T^1(\alpha)$ is the same as our $T(\alpha)$. To compute the table they used an ingenious expansion devised by Mr. Goch. This method has unfortunately not yet been published, but I am indebted to Mr. Goch for making the details of the method available to me.

At the same time an independent investigation had been started dealing with values of α from 0 to 1,000,000, as stated in a previous publication by Wiles (1939). This work has been completed and has given values of $T(\alpha)$ in agreement with those given by Patterson and Goch. In addition the behaviour of $T(\alpha)$ has been investigated as α tends to 0 in one direction and to ∞ in the other direction. In a similar way the function $Q(\alpha)$ tabulated by Patterson and Goch has been checked by an independent method, and the range of α extended to 0 and to ∞.

The following paragraphs are a brief report on this work.

2. *Method for Values of* α *between* 0 *and* 1,000,000.

Following the formal solution given by Nicholson or by Carslaw and Jaeger, we can show that the function $T(\alpha)$ given by

$$T(\alpha) = \int_0^\infty \frac{4}{\pi^2} \frac{e^{-\alpha\lambda^2}}{J_0^2(\lambda) + Y_0^2(\lambda)} \frac{d\lambda}{\lambda} \qquad \text{.....................(2)}$$

where J_0 and Y_0 are Bessel's functions. The infinite range of this integral was divided up into seven smaller ranges, namely, ranges namely, 0 to λ_1, λ_1 to λ_2, ..., λ_6 to ∞, where the values of λ_1, λ_2, ... are seen in the second column of Table 1.

n	λ_n	A_n	B_n	C_n
0	0	0	0	0
1	0·00008	0·0288	25·1	−0·000,000,373
2	0·0004	0·0432	8·09	−0·000,003,64
3	0·003	0·0732	3·13	−0·000,052,6
4	0·02	0·1216	1·85	−0·000,548
5	0·1	0·158	1·53	0
6	2	0	$\pi/2$	$+\pi/16$
7	∞	0	0	0

TABLE 1.

In the first range we used the approximation $e^{-\alpha\lambda^2} = 1$. This is accurate to within 1% throughout the range for all values

of α from 0 to well beyond 1,000,000. By using in addition the approximation

$$J_0^2(\lambda) + Y_0^2(\lambda) = 1 + \frac{4}{\pi^2}\left[j + \ln\frac{\lambda}{2}\right]^2 \quad \text{.................(3)}$$

which is accurate to about one millionth part of 1%, we can perform the integration (j is Euler's constant, and ln denotes log to base e). The contribution to $T(\alpha)$ from this first range is 0.1038.

In each of the other six ranges we used the approximation

$$\frac{1}{J_0^2(\lambda) + Y_0^2(\lambda)} = A_n + B_n\lambda + \frac{C_n}{\lambda}$$

where the values of A_n, B_n, and C_n are shown in Table 1. These approximations are accurate everywhere to within 1%. The integrations can be performed, and we arrive finally at $T(\alpha)$ as the sum of twenty-seven terms involving exponentials, error functions, and exponential-integral functions. The accuracy of this final result can be expected to be considerably better than 1%, since the error introduced into the integral was positive for some values of λ, negative for other values of λ, and nowhere exceeded 1%.

In a similar way the function

$$Q(\alpha) = \int_0^{\alpha} T(\alpha)\,d\alpha$$

was dealt with. The same approximations were used for the Bessel's functions as before, but the further details of method will be omitted here.

3. *Numerical Results.*

The tables of Patterson and Goch for $T(\alpha)$ and $Q(\alpha)$ were checked at seven different values of α distributed within their range $\alpha = 0.01$ to $\alpha = 1000$. Our values agreed with their values at all points with an accuracy much greater than 1%.

Some additional values obtained outside their range of values of α are shown as follows:—

TABLE 2

α	$T(\alpha)$	$Q(\alpha)$
10,000	0·196	2,200
100,000	0·160	17,600
1,000,000	0·136	146,000

4. *Values for small α.*

Our approximation has given $T(\alpha)$ as the sum of twenty-seven terms involving exponentials, error functions and exponential-integral functions. For small values of α these various

functions can be expanded into series consisting mainly of positive powers of a. Collecting like powers together, we find

$$T(a) = 1/\sqrt{(\pi a)} + 0\cdot501 + O(a^{\frac{1}{2}})$$

where $O(a^{\frac{1}{2}})$ denotes terms in $a^{\frac{1}{2}}$ and higher powers. Similarly for small values of a we find

$$Q(a) = 2\sqrt{(a/\pi)} + O(a)$$

5. *Values for large* a.

When a is sufficiently large the integral in equation (2) can be taken between the limits o and m where m is a constant lying between 0 and 1. Then the substitution $\lambda^2 = \mu$ together with the use of equation (3) gives

$$T(a) = 2\int_0^{m^2} \frac{e^{-a\mu}}{(\ln\mu)^2}\,\frac{d\mu}{\mu}$$

From this we can derive a lower limit and an upper limit for the value of $T(a)$. We can show that $T(a)$ is greater than

$$2\int_0^{1/a} \frac{1-a\mu}{(\ln\mu)^2}\,\frac{d\mu}{\mu} = \frac{2}{\ln a}\left[1-\frac{1}{\ln a}\right]$$

and we can show that $T(a)$ is less than

$$2\int_0^{2/a} \frac{1-a\mu}{(\ln\mu)^2}\,\frac{d\mu}{\mu} = \frac{2}{\ln a}\left[1-\frac{1-\ln 2}{\ln a}\right]$$

where in the last equation we have neglected higher powers of $1/\ln. a$. Thus finally when a is large we can write

$$T(a) = \frac{2}{\ln a}\left[1-\frac{A}{\ln a}\right]$$

where A varies with a, but must lie between 0.3 and 1.

In a similar way we can deal with $Q(a)$ and show when a is large

$$Q(a) = \frac{2a}{\ln a}\left[1+\frac{B}{\ln a}\right]$$

where B varies with a, but must lie between 0 and 0.7.

6. *Conclusion.*

The values given by Patterson and Goch for $T(a)$ and $Q(a)$ from $a = 0.01$ to $a = 1000$ may be regarded as established. Some values of $T(a)$ and $Q(a)$ for larger values of

α are given in Table 2. For very large values of α, T(α) goes to 0 like $2/\ln \alpha$, and Q(α) goes to ∞ like $2\alpha/\ln \alpha$, where ln denotes log to base e. For very small values of α, T(α) goes to ∞ like $1/\sqrt{\pi\alpha}$, and Q(α) goes to 0 like $2\sqrt{\alpha/\pi}$.

7. *Acknowledgement.*

This work is part of an investigation taking place in the Dust and Ventilation Department of the Transvaal Chamber of Mines. I am indebted to the Chamber for permission to publish this paper.

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BY-PRODUCTS FROM WOOLWASHERIES

BY

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Normally the Union produces about 240 million pounds of grease wool. At present 11 woolwasheries operating in the Union scour about 50 million pounds. Most of the washeries are small and some of them have only been able to carry on as the result of local wartime demands for scoured wool. A few of these are subeconomic units and also in a sad state of repair, and will probably go out of competition when better scoured products are again demanded at competitive prices. Their places will be taken by projected new plants of modern design and competitive output.

Against these it is gratifying to be able to set-off a few sound concerns where pride of product is also the first consideration. Some of these can well compete with the best overseas washeries.

The 50 million pounds of locally scoured wools are mostly of inferior types, including lox, bellies, pieces, coarse and coloured, karakul, mohair, etc. These are scoured locally mainly because of their low clean wool yields, e.g., lox contain on an average less than 30 per cent. of clean wool. By exporting the scoured wool much freight is saved.

There is a further reason why some of these types, especially lox, are scoured locally. When such wool is compressed, as for export, rapid deterioration and discolouration takes place, so that much of its value is lost. When such wools are compressed the fibres are virtually embedded in an alkaline liquid medium damaging and staining them. Before the War a fair amount of local lox was exported in the raw state, but this can now be considered as an obsolete practice, and at least a steady 50 million pounds per annum can be expected to be available for local washeries. A small quantity of lambs' wool and special blanket types are also scoured locally, and a small quantity of fleece wool will also have to be scoured here in order to supply the wool mill operating at Uitenhage, and others in the process of erection.

Before the War, local firms started to export scoured fleece wool on their own account and a good market was opened. A demand for scoured wool was also made by the smaller continental countries. A post-War development in this direction may thus be expected.

The Union wool clip consists of an average of 48 per cent. of pure wool, and this compares favourably with similar types from Australia. The balance is made up approximately as follows:—

Grease	17 per cent.
Suint	10 „ „
Vegetable matter	3 „ „
Mineral	22 „ „

Calculated on the total clip the grease represents over 40 million pounds weight and the suint about 24 million pounds. Wool grease consists of a mixture of esters of high molecular weight, where the acidic portion may be one of the following fatty acids:—

1. Normal $CH_3(CH_2)_n.COOH$ where n = 8-24
2. Iso- $CH_3.CH(CH_2)_n.COOH$ „ „ = 7-25
   CH_3
3. Anteiso- $CH_3.CH_2.CH.(CH_2)_n.COOH$ „ „ = 4-26
   CH_3
4. a Hydroxy $CH_3(CH_2)_n.CHOH.COOH$ „ „ = 11-13

Last year Weitkamp and his team of workers in America carried out these analyses with a molecular still. Except for the hydroxy acids the analyses of the other three groups can be considered to be almost conclusive. The hydroxy acids represent only a low percentage of the total fatty acids and can unfortunately not be determined by the same method when mixed with other fatty acids. For the purpose of these analyses the freed fatty acids were first converted to the methyl esters, and sharp distillations were obtained.

At present a team of British workers is engaged on the alcoholic portion of the ester and very interesting results can soon be expected. It is known that up to 35 per cent. of this portion may consist of cholesterol, while the balance is made up, as far is known, of straight chain aliphatic alcohols and two triterpenes, agnol and lanol, which are, unscientifically, still referred to as agnosterol and lanosterol respectively. The full structures of these two are not yet known. The rings appear to be arranged similarly to those of cholesterol, with more double bonds in the rings and side chains.

(Cholesterol—Vitamin D_3 structure.)

If the possible permutations and combinations of these acids and alcohols are taken into account then it will be realised what a heterogeneous and variable mixture wool grease is and what difficulties are encountered in research on this product, e.g., it is well known that the metallic salts of the higher fatty acids, C_{22} and above, more often than not, behave differently to those of the C_{12} to C_{18} series as regards solubility and some other

properties. To aggravate the situation the change in behaviour is usually gradual, and very little is known of the anteiso series. As an instance, whereas the potassium soaps in the C_{16} series are soluble in water and insoluble in petroleum ether, those close to C_{26} behave differently. Even the saponification of wool grease is a problem. Fairly concentrated ethoxide has to be used for an extended period.

Strictly speaking, wool grease or lanolin is the product of the excretion of the sebaceous glands of the sheep. Actually it contains small quantities of interaction products between grease and suint.

Suint is the alkaline aqueous excretion of the sudoriferous glands. It is much more complex than human perspiration and will supply the first year student with most of his group test elements and radicles. In contradistinction to human perspiration, suint contains potassium and sodium in the ratio of 25 to 1. The dried material actually contains about 25 per cent. of potassium as K. Amongst others, it also contains a fair amount of manganese, which seems to be a physiological constituent.

Under natural conditions the potassium carbonate in the suint will react with a small amount of the acid constituents of the grease to form water soluble soaps. On the other hand, the water soluble extract will contain many organic constituents insoluble in petrol ether. Between the two glandular excretions are also to be found the products of urinary excretion and faeces, normal and pathological. It is thus not strange that wool grease contains, amongst others, practically all the sex hormones. An arbitrary definition of wool grease will thus be: The dry petroleum ether extract of natural greasy wool. Suint then becomes the water extract after petrol ether exhaustion.

There are many commercial systems of wool grease extraction in existence. Wool is usually scoured in a solution of soap and soda in three to five successive bowls in tandem. The first two bowls, which usually do the dirty work, are built up to two per cent. of grease.

In England the popular method of extracting wool grease is the acid cracking system. The effluents from all except the rinsing bowls are combined and run into large lead-lined tanks. Sulphuric acid is added to the correct pH. The cracked coagulum is hot pressed and the grease separated from the aqueous phase. This system has the advantage of recovering the soap fats in addition, but the grease has a very dark colour and a most undesirable odour. The process is also laborious and expensive. The type of grease obtained is known as Yorkshire grease.

During the War a gigantic recovery plant and refinery was erected at Esholt, near Bradford. The effluents of many washeries are now pooled and treated at Esholt, where the grease is

also refined and turned into secondary products. Most of the soap is thus also recovered. To-day there are over a hundred different secondary wool grease products and the majority of them are successful competitors with existing products. In many cases there is no competition.

The centrifugal system is favoured in America. Here the effluent from the first two bowls only is utilised. First the mud is eliminated in a special continuous centrifuge and then the grease is extracted and purified in super centrifuges. The grease being separated freshly from an alkaline medium is of a very light colour and may sometimes be sold as pharmaceutical lanolin without any further purification. Here the extraction costs are much lower, but so is the efficiency, being usually about 40 per cent. The centrifugal system has the further advantage that it is possible to apply suint scouring, which results in a considerable saving of soap and soda.

Locally wool grease extraction is practised on a small scale. It is a modified method of a system used in England before the first world war. It appears, however, that one or two local washeries intend installing the centrifugal system. For this type of grease there should be a good local market.

Before the War potash recovery was carried out on a small scale only, overseas, except in Germany. Locally, where mostly lox is scoured, this should be highly remunerative. The effluent from lox contains a very high percentage of potash. The potash in the local wool clip just supplements the South African normal imports.

More research has been carried out on wool grease during this War than ever before. The reason for this is that both England and the U.S.A. had on hand huge stocks of crude wool grease. Shipping being paralysed, these stocks were exploited as substitutes for other products. The result was that research on a gigantic scale had to precede the practical utilisation of these stocks. The results were most gratifying.

In England this research is being continued. Australia is now starting such research on an even bigger scale. South Africa may also contribute to a small extent in the future.

GEOGRAPHY AS A PIVOTAL SUBJECT IN EDUCATION

BY

PROF. F. E. PLUMMER.

Read 4th July, 1946.

A NOTE ON THE FIRST RECORD OF STONE-IMPLEMENT-COLLECTING IN SOUTH AFRICA

BY

DR. J. HEWITT.

Read 3rd July, 1946.

SOME ASPECTS OF THE MILK INDUSTRY IN SOUTH AFRICA, WITH SPECIAL REFERENCE TO PASTEURIZATION

(Symposium on Milk Industry)

BY

DR. E. M. ROBINSON.

Read 3rd July, 1946.

SURFACE WATERS

(Symposium on "Water Resources of S. Africa")

BY

D. F. ROBERTS.

Read 1st July, 1946.

UNDERGROUND WATERS

(Symposium on "Water Resources of S. Africa")

BY

DR. H. F. FROMMURZE.

Read 1st July, 1946.

RELEASE OF ATOMIC ENERGY

BY

PROF. W. F. BEEZHOLD.

Popular Evening Lecture. Read 2nd July, 1946.

CALCIUM AND PHOSPHORUS IN POULTRY RATIONS

BY

A. M. M. GERICKE.

Read 3rd July, 1946.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 124-157, July, 1947.*

NOTES ON EASTERN CAPRIVI STRIP

BY

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With one map, one chart and ten figures.

Read 3rd July, 1946.

INTRODUCTION.

Probably one of the least known territories of Africa is the Caprivi Strip (1), which extends east from the Ovamboland portion of South-West Africa Protectorate like a dagger into Rhodesia, the heart of the Sub-continent. The area to be described is that east of the Kwando River (also known as Mashi, Linyanti or Chobe), and its extent is approximately 4,500 square miles. The main tribes are the Mafwe, located chiefly along the east bank of the Kwando, the Mayeyi, who mainly occupy the country along the swamps of the same river, and finally the Masubia, who inhabit the eastern grasslands subject to annual inundation of the Zambesi. The total population is approximately 12,000 and the herds number 26,000 head of cattle, 1,200 goats and 77 donkeys (November, 1945).

Almost the entire Native population lives along the banks of the two rivers or in the eastern one-fifth which is subject to annual inundation. Away from these regions there are wandering Bushmen and Mambukushu, who eke out a precarious existence in the bush-covered waste (2).

As the country forms part of the vast Kalahari sand plateau, the margin of safety between normal carrying-capacity of livestock and overstocking (and so wind erosion) is delicate, in spite of deep-rooted forest and surface grass growth. Thus the export *via* Northern Rhodesia of any surplus cattle is encouraged. Communicable diseases are rare.

Politically the territory became German in 1890, but it was only in 1909 that Hauptmann Streitwolf (1911) assumed the post of Kaiserlicher Resident, with headquarters at Schuckmannsburg. On the outbreak of the First Great War, the Strip was seized by Southern Rhodesia troops and the District Commissioner was removed from office. After a short period, the territory was administered through the High Commissioner as part of Bechuanaland Protectorate. In 1930 administration was

taken over by the South-West Africa Protectorate authorities (*vide* Caprivi Zipfel Affairs Proclamation 27 of 1930), but owing to inaccessibility from Windhoek, the capital, the Eastern Caprivi from August, 1939, has been administered by the Native Affairs Department at Pretoria (*vide* Proclamation No. 147 of 1939).

The Natives, in spite of a tropical climate, are well nourished and contented, the administration from Katima Mulilo being efficient and benevolent; as is indicated by the exemption from tribal levies in terms of Government Notice No. 2539 of 21st December, 1945.

Three main forms of agriculture are practised by the inhabitants:—

(1) Bush gardens, in the unflooded areas, where cassava, millet and kaffir corn thrive in the summer months;

(2) pre-summer gardens of maize, pulses and cucurbits in the flooded regions, planted as soon as the waters recede in July; and

(3) summer lands, once subject to flooding, but which are now dependent on summer rains. There big yields of grain are harvested.

The Eastern Caprivi may be reached by one of four ways:—

(a) A train journey of 155 miles by the Zambesi Sawmills Railways from Livingstone to Masese, which is 30 miles east of Katima Mulilo;

(b) a journey by Witwatersrand Native Labour Association's bus from Victoria Falls to Kasane, *via* New Kasungula, distance 75 miles. Kasane (in Bechuanaland Protectorate) is 76 miles from Katima Mulilo, which can be reached by motor car;

(c) a journey up the Zambesi River from Livingstone *via* Kazungula to Katima Mulilo; and

(d) last, but speediest, by aeroplane to Katima Mulilo, where there is an aerodrome.

The potentialities of the country are vast and include exploitation of timber, *e.g.*, Rhodesian teak (*Baikiaea plurijuga*), irrigation and the cultivation of food and economic crops, encouragement of the tourist industry, and utilisation of river transport. Meanwhile the Caprivi slumbers.

ENVIRONMENTAL FACTORS.

A. *Topography.*

Actually the only land border is the 60 miles direct line adjacent to the Barotseland province of Northern Rhodesia, for the rest is made up of the area situated at the confluence of the

Zambesi and Kwando Rivers. Although constituting the western and southern borders of the Territory, the Kwando, after forming the swamps, is relatively a small river, and in some years it has been reported (3) (1944, Mr. T. Crystal, Kasane—1945, Mr. v. Staden, through Major L. Trollope, Katima Mulilo) to cease flowing, indeed to such an extent that one may cross it dry shod. The Zambesi River is the main source of life of the Eastern Caprivi for it inundates the eastern one-fifth of the country, providing ample pasturage for cattle, as well as food, including fish, for the main tribe, the Masubia. The country is flat and sandy, having an altitude of slightly over 3,000 feet, the northern portion (*i.e.*, along the Northern Rhodesia boundary) being higher than the southern. Apart from a few summer pans in the interior, due to rain, all the water of the Territory, either surface or subterranean, is derived from the two rivers referred to above.

Flood Levels:

(a) Zambesi River taken at Katima Mulilo. Thanks to the Magistrate (4) of the Eastern Caprivi Strip (letter 2/18/7-1 of 22nd March, 1946) the following particulars are available:—

"Recordings were started at Katima Mulilo on 18th January, 1940, but they are unfortunately not complete. I give below the 1940 figures as recorded and later readings at intervals that should be sufficient to show the general rate of rise and fall and the extent:—

1940.	*From low-water.*	1940.	*From low-water.*
January 1st	4′ 3″	April 12th	22′ 6″
January 8th	4′ 9″	April 13th	22′ 3″
January 15th	5′ 2″	April 14th	22′ 1″
January 22nd	5′ 11″	April 15th	21′ 11″
January 29th	6′ 8″	April 16th	21′ 8″
February 5th	7′ 1″	April 17th	21′ 6″
February 12th	7′ 6″	April 18th	21′ 3″
February 19th	8′ 3″	April 19th	21′ 1″
February 26th	10′ 2″	April 20th	21′ 1″
March 4th	13′	April 21st	21′ 1″
March 11th	14′ 7″	April 22nd	21′
March 18th	18′ 6″	April 23rd	20′ 11″
March 25th	19′ 10″	April 24th	20′ 9″
April 1st	21′ 9″	April 25th	20′ 8″
April 6th	23′ ½″	April 29th	19′ 11″
	(Peak)	May 6th	18′ 1″
April 7th	23′	May 13th	16′ 6″
April 8th	22′ 11″	May 20th	15′ 1″
April 9th	22′ 11½″	May 29th	13′ 9″
April 10th	22′ 10½″	June 3rd	12′ 6″
April 11th	22′ 10½″	June 10th	11′ 2″

1940.	*From low-water.*
June 17th	10′
June 24th	8′ 7″
July 1st	7′ 4″
July 8th	6′
July 15th	5′
July 22nd	4′ 3″
July 29th	3′ 8″
August 5th	3′ 1″
August 12th	2′ 8″
August 19th	2′ 2″

1940.	*From low-water.*
August 26th	2′
September 2nd	1′ 10″
September 9th	1′ 8″
September 16th	1′ 7″
September 23rd	1′ 4″
September 30th	1′ 1″
October 7th	10″
October 14th	9″
October 21st	8″
October 28th	10″

1941.	
November 21st	4″
November 28th	6″
December 7th	7″
December 14th	8″
December 31st	1′ 3″

1942.	
January 14th	1′ 11″
January 28th	2′ 10″
February 14th	3′ 11″
February 28th	5′ 7″
March 14th	7′
March 31st	8′ 11″
April 14th	14′ 2″
April 28th	15′ 6″ (Peak)
April 30th	15′ 3″
May 14th	12′
May 31st	9′ 4″
June 9th	6′ 9″

1943.	
January 1st	1′ 4″
January 14th	2′ 3″
January 31st	2′ 3″
February 14th	3′ 5″
February 28th	4′ 8″
March 14th	5′ 11″
March 31st	10′ 10″
April 14th	12′ 9″ (Peak)
April 30th	12′ 4″
May 14th	12′ 3″
May 31st	10′ 8″
June 14th	8′ 8″
June 30th	5′ .2″
July 14th	3′
July 31st	1′ 10″
October 11th	1″
November 12th	2″
December 31st	1′ 9″

1944.	
January 1st	1′ 10″
April 18th	16′ 8″ (Peak)

1945.	
January 1st	2′
March 21st	19′ 3″ (Peak)

1946.	
January 1st	2′
February 1st	5′ 3″
March 1st	6′ 10″
March 18th	9′

The 1940 level was exceptional. There was a very high flood in 1934, some say higher than 1940, others say lower.

As the Zambesi rises above its southern bank in the eastern part of the strip, the level of the flood determines the extent of inundation, and thus influences the lives of the people in that area, whose villages are on what might be called mounds —slightly higher than the general plain."

(b) The Mashi River. Captain C. E. Kruger gives the details which follow:—

"As a rule the Mashi (or Chobe) near Singalamwe starts rising in May, reaching high water mark in June. The rise is slow and variable but normally not more than a few feet in the river proper. The water flows fairly swiftly until it reaches the Chobe swamps where it disperses. To-day the flood waters do not, I believe, normally go much beyond Linyanti. Lower down the Chobe benefits from water that comes across the Strip from the Zambesi (by way chiefly of the Kasaia channel).

"The Mashi depression at Singalamwe and lower down is two miles and more wide. The flood waters escape from the main stream into 'molapos' and low-lying places within the depression. These arms and waterways wind in all directions."

B. *Climate.*

Rainfall.—The region of highest mean annual rainfall in Africa is to be found along the north shore of the Gulf of Guinea, especially at the head of the Gulf, where, according to the rainfall map of Africa compiled by Kincer, J. B. (Shantz and Marbut, 1923), the annual precipitation may be as much as 400 inches. Arranged about this main centre in elliptical fashion, the axis having an east to west direction, are the rainfall regions of less annual precipitation, namely, the following:—

(a) Up to 150 inches in a region immediately adjacent to the centre of maximum precipitation—the Cameroons coast and the littoral of Liberia.

(b) Again immediately about (a) is the isohyet representing 100 inches.

(c), (d), (e) and (f). Again about the rainfall region of 100 inches are the isohyets of 80, 60, 50 and 40 inches

respectively, the eastern pole of the main axis extending further across Africa as the lower rainfall areas are encountered.

Finally the isohyet representing 40 inches appears on the west coast of Africa near Bathurst and extends in an easterly direction approximately along the 12° line of latitude, up to the Nile. There it swings south through Uganda, Kenya, Tanganyika and Mozambique, but always to the east of the Great Lakes. From the southern end of Lake Nyasa the line proceeds west in the direction of Mossamedes in Angola, skirts the Bihe Plateau and proceeding north leaves the West African coast at Kabinda, near the Congo mouth. Outside the isohyet in question are those of still less rainfall, e.g., 30, 20 and 10 inch regions.

The isohyets are more or less parallel along their course except in East Africa, where owing to other rainfall regimes, *e.g.*, Abyssinian Highlands, the rainfall is not related to that of the tropics mentioned above.

Now, in which region does the Caprivi Strip, particularly the eastern part, lie? Kincer places the Territory in the region of 30—40 inches mean annual rainfall, Kasane, no doubt one of the 656 stations consulted, lying just within it, and Katima Mulilo well within.

The information, however, available from Kasane (25 years) and Katima Mulilo (11 years), given below, indicates that the average rainfall is approximately 26.62 inches a year.

Kasane was opened in November, 1920, as a station where not only rainfall, but other meteorological data are obtained. Katima Mulilo, however, while serving as a rainfall record centre from March, 1935, did not include other data until April, 1940. Unfortunately owing to the departure of the military garrison at the end of March, 1944, only rainfall records continue to be taken (5).

It is possible, therefore, to compare rainfall figures at the two stations from March, 1935.

All available reliable data will be discussed, and in addition a chart is provided where records collected from 1940 to 1944 are compared diagrammatically in regard to rainfall and mean maximum temperatures.

Katima Mulilo (Lat. 17° 30′; Long. 24° 07′; Altitude 3117 ft.)

(i) *Rainfall.*—The monthly, mean monthly and mean annual rainfall in inches are tabulated below:—

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1935 ..			2.13	0.21	0.50	0.00	0.00	0.00	0.01	0.11	1.35	4.59	8.90
1936 ..	4.50	3.78	9.47	0.11	4.70	0.00	0.00	0.00	0.00	1.06	3.31	2.84	29.77
1937 ..	3.28	10.23	2.65	0.04	0.00	0.00	0.00	0.00	0.00	0.07	0.65	3.69	20.61
1938 ..	4.89	4.99	0.63	0.08	0.00	0.00	0.00	0.00	0.05	1.14	5.50	7.27	24.55
1939 ..	8.64	8.92	5.96	0.00	0.00	0.03	0.00	0.01	1.06	1.87	3.81	11.10	41.40
1940 ..	3.86	3.86	9.89	0.00	0.00	0.00	0.00	0.00	0.09	0.30	3.30	6.23	27.53
1941 ..	10.20	5.75	0.30	1.57	0.00	0.00	0.00	0.00	0.00	0.24	2.11	4.67	24.84
1942 ..	5.79	1.11	2.80	0.16	0.00	0.00	0.00	0.00	0.00	1.99	1.84	3.33	27.02
1943 ..	3.03	5.91	1.33	5.49	0.01	0.00	0.00	0.00	0.00	0.00	8.11	3.65	27.53
1944 ..	10.56	12.01	3.31	0.00	0.00	00.0	0.00	0.00	0.00	0.52	2.59	2.90	31.89
1945 ..	6.60	1.15	4.06	0.00	0.14	0.00	0.00	0.00	0.00	0.89	3.98	4.94	21.76
1946 ..	11.18	7.57											18.75
Total ..	72.53	65.28	42.53	7.66	5.35	.03	0.00	0.01	1.21	8.19	36.55	55.21	304.55
Mean ..	6.6	5.93	3.86	.69	.49	.002	0.00	.0001	.12	.74	3.32	5.02	

The annual mean rainfall over 11 years is 27.68 inches.

• The recording of *the days* on which rain fell only commenced in April, 1940. Previous to this the total rainfall alone was recorded.

(See Chart for representation of monthly precipitation as compared with Kasane.)

(ii) *Temperature*. The mean *maximum* temperatures for each month are tabulated below :—

Year	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
1940				83.5	80.5	77.0	77.6	84.4	93.8	90.9	92.1	90.9
1941	82.7	85.7	87.5	88.0	84.3	80.1	79.2	85.3	92.0	95.3	94.3	86.1
1942	86.9	90.2	87.6	88.0	86.0	83.0	77.4	85.7	93.7	90.5	91.9	88.6
1943	87.3	85.3	86.9	84.5	82.9	77.6	81.3	84.3	90.3	98.7	86.9	83.0
1944	83.2	81.7	83.9									
Total ..	340.1	342.9	345.9	344.0	333.7	317.7	315.5	339.7	369.8	375.4	365.2	348.6
Mean ..	85.	85.7	86.5	86.0	83.4	79.4	78.9	84.9	92.5	93.8	91.3	87.2

The hottest day (absolute maximum) occurred in October and again in November, 1941, when the reading was 103 deg. The coolest day with a maximum of 82 deg. was experienced in July, 1942.

The mean *minimum* temperatures are not given owing to broken records and possible errors. There is, however, sufficient evidence to indicate that the graph compares fairly well with that of Kasane which is shown. The distance across country from Katima Mulilo to Kasane is only 60 miles.

Frost. According to the Magistrate, Eastern Caprivi Zipfel (letter 2/18/7-1 of 22/3/46) " in 1941 . . . there was a very severe frost on 1st of July, such that sub-tropical fruits . . . suffered badly, the indigenous trees to a lesser degree. My recollection is that the frost followed a high cold wind. The temperature dropped (to 31° at Kasane). Judging by the appearance of trees and by statements made by the people the condition was the same throughout the territory . . . Major Trollope informed me that in 1945 there was another severe frost, the intervening years being normal."

(iii) *Relative Humidity*. For the same reason just given the figures and graph for the mean monthly relative humidity from April, 1940 to March, 1944 are not given. The graph for Kasane is shown and as would be expected there is a fair agreement. *Kasane* (6) (Lat. 17° 48′; Long. 25° 09′; Altitude 3,000 ft.).

(i) *Rainfall.* Records have been taken since November, 1920 and according to the Meteorological Department's Blue Book (U.G. No. 6 of 1938) the mean annual rainfall for the period 1920-35 is 25.01 inches.

It is proposed to consider here the data accumulated since January, 1936, and to calculate from it the (a) mean monthly and (b) mean annual rainfall until December, 1945, *i.e.* 10 years. The figures are as follows :—

(a)	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Total 10 years	58.41	72.19	43.10	11.61	2.68	.50	0.00	0.06	1.75	8.36	28.6	53.70	280.96
Mean ..	5.84	7.22	4.31	1.16	.27	.05	0.00	.006	.18	.84	2.86	5.37	28.09

(b) The mean annual rainfall for the last 10 years is therefore 28.09 inches. From the above it is evident that the mean annual rainfall over 25 years is 25.57 inches.

Within the past ten years rain has fallen on 21 days in February, 1937, and as little as six days in February, 1943, February being with January the months of greatest precipitation.

It is rare that rain falls during the months of May to September, July and August being invariably dry.

(See diagram comparing the rainfall with that of Katima Mulilo during the period 1940-44.)

(ii) *Temperature.* The mean maximum temperatures for each month (taken over a period of 15 years) are shown below :—

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
87.5	87.3	87.6	86.6	82.9	78.6	80.5	83.3	92.6	95.9	91.9	87.5

The hottest day (absolute maximum) occurred in October, 1943, when the reading was 108 deg. The coolest day with a maximum of 81 deg. was recorded in June, 1934.

The mean *minimum* temperatures for each month taken over the same period are shown hereunder :—

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
65.6	65.2	64	60.4	53.6	44.6	46.9	50.5	52.2	65.1	62.2	65.4

The coldest night (absolute minimum) was registered in June, 1941, when the temperature was 31 deg. The warmest night occurred in January, 1931 when the temperature was 65 deg.

(See chart comparing mean maximum temperatures for each month during 1940-44.)

(iii) *Relative Humidity.* The mean relative humidity for each month over 15 years ending December, 1945, is shown below :—

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean ..	72.0	75.0	69.0	64.0	54.0	55.0	54.0	47.0	45.0	42.0	57.0	68.0

(See chart representing relative humidity at Kasane.)

(c) *Soil.*

Marbut (Shantz and Marbut, 1923) places the Caprivi east of the Okavango River (excluding the alluvial banks of the Kwando River) in the Red Loams region which includes the greater part of Angola, Northern Rhodesia and parts of Mozambique, Tanganyika, Uganda, French Equatorial Africa and Abyssinia. Indeed the Caprivi Strip is the southern part of this vast Central African Red Loams region. It should be stressed that the authors emphasise that "it is impossible at the present time to construct a soil map of Africa" (p. 137), so Marbut's attempt must be considered as entirely provisional. Indeed no soil samples appear to have been collected in Northern Rhodesia during Shantz's journey from Cape Town to Cairo in 1919-20.

Trapnell and Clothier have in their ecological surveys of North-Western Rhodesia (1937) and North-Eastern Rhodesia (1943) made valuable contributions to soil science. Henkel (1931) gives a useful summary of the soils of Southern Rhodesia.

Ten samples of soil were collected by the author in Caprivi in October, 1945, and, thanks to the Director of the Division of Chemical Services, the report on them is as follows:—

"The soil samples . . . have been classified by you into

(a) Soils not subject to flooding, and

(b) soils subject to flooding.

In the following table the salient features . . . are given:—

(a) *Soils not subject to flooding*:

Sample B.4888 (No. I), brownish grey, loose sand, deficient in organic matter and roots; pH (soil reaction) 8.1 and resistance at 60° C. of 1,600; Nitrate-Nitrogen medium, Ammonia-N. high, Phosphorus (P.) low, Potash (K.) very high, Calcium (Ca.) very high.

Sample B4889 (No. III), bluish grey, crumbly sandy loam, deficient in humus, roots medium; pH 8.3, resistance 850; Nitrate high, Amm. medium, P. trace, K. very high, Ca. very high.

Sample B4890 (No. VI), dark greyish brown, coherent sandy loam, abundant humus, roots plenty; pH 7.9, resistance 650; Nitrate high, Amm. medium, P. low, K. medium, Ca. very high.

Sample B4891 (No. VIII), light grey, slightly coherent sand; humus deficient, roots few; pH 6.9, resistance 3,300; Nitrate trace, Amm. high, P. trace, K. high, Ca. low.

Sample B4892 (No. IX), light grey, loose sand, humus deficient, roots few; pH 5.9, resistance 10,000; Nitrate trace, Amm. low, P. low, K. low, Ca. trace.

(b) *Soils subject to flooding*:

Sample B4893 (No. II), dark greyish brown with bluish

tint, slightly coherent sand, abundant humus, roots plenty; pH 6.9, resistance 760; Nitrate medium, Amm. low, P. trace, K. high, Ca. high.

Sample B4894 (No. V), dark greyish brown, granular to crumbly very fine silty sand, humus and roots medium; pH 6.9, resistance 1,300; Nitrate low, Amm. medium, P. trace, K. very high, Ca. very high.

Sample B4895 (No. VII), dark greyish brown with bluish tint, crumbly fine sandy silt, humus high, roots fair; pH 5.8, resistance 1,300; Nitrate high, Amm. low, P. trace, K. trace, Ca. very high.

Sample B4896 (No. X), dark greyish brown with bluish tint, granular to crumbly fine sandy silt, humus high, roots fair; pH 6.1, resistance 670; Nitrate very high, Amm. medium, P. trace, K. trace, Ca. very high.

Sample B4897 (No. IV), dark bluish grey fine sandy loam, humus high and roots rather poor; pH 6.4, resistance 2,700; Nitrate trace, Amm. medium, P. low, K. medium, Ca. very high.

Soils from Bechuanaland Protectorate:

Sample No. B4898 (No. XI), light brown stony sand, loose, deficient in humus, roots few; pH 6.4, resistance 2,500; Nitrate medium, Amm. trace, P. trace, K. medium, Ca. very high (not subject to seasonal flooding).

Sample No. B4889 (No. XII), bluish grey, slightly coherent fine sand, humus medium, roots fair; pH 6.4, resistance 1,900; Nitrate low, Amm. medium, P. trace, K. low, Ca. very high (subject to annual flooding by Kwando River).

Judging from the colour, nature of the organic material and texture of these soil samples, I consider them all of transported origin (wind and waterborne). To my mind the samples excepting B4898 can be classified into two main types:—

(a) Those subject to flooding and swampy conditions, and
(b) those which are subject to temporary waterlogging as a result of relatively poor internal drainage.

Although the sub-soils and sub-strata of these latter soils are unknown to me, I have a strong suspicion that a rather compact and fairly impervious layer exists in each of the profiles which have been classified by you as not subject to flooding. These impervious layers are responsible for the temporary waterlogged conditions.

The soils are free from soluble salts and have soil reactions ranging from "slightly acid" to "fairly alkaline". Their fertility, as determined by the Rapid Test method, varies considerably. The nitrate-nitrogen ranges from a "trace" to "very high", the ammonia-nitrogen from a "trace" to "high", the phosphorus from a "trace" to "low", the potash from a

" trace " to " very high ", and the calcium again from a " trace " to " very high." (Letter No. C.30/7 of 30th January, 1946.)

Whatever the chemical analysis may be, it is of interest to note that in soil from which—

(a) Sample B4888 was taken, a good crop of bulrush millet was grown in 1945;

(b) Sample B4893, native tobacco and cucurbits were growing well in October, 1945;

(c) Sample B4896, good crops of mealies and monkey nuts were growing in October, 1945; and

(d) Sample B4897, a good crop of mealies had been grown in 1945.

It is clear that Marbut's view (his soil map, plates I and II of American Geographical Society's Research Series refers), that the two chief types of soil in the Eastern Caprivi are alluvium and red loam, will have to be revised.

Further, it is only Shantz and Marbut who have endeavoured to assess both the agricultural potentiality of the land and the type of its utilisation in the territory. Their views with the authors' remarks are summarised below as follows:—

					Remarks:
(a) Agricultural potentiality	Away from river valleys i.e., sandveld	Fair	Along valleys	Poor	The reverse is the position.
(b) land utilisation:					
(i) For Agriculture	Away from river valleys i.e. sandveld	High productivity	Along valleys	No reference	The reverse is the position
(ii) For grazing	Away from river valleys, i.e. sandveld	Low productivity	Along valleys	Medium	This is more or less the case.
(iii) for indigenous forest	Away from river valleys i.e. sandveld	High productivity	Along valleys	Very low productivity	This is more or less the case.

A point to be stressed is that, although tropical, owing to the late rains the growing season is shorter than in South Africa.

Unfortunately little attention is devoted by these authors to altitude, an important factor in dealing with environmental conditions.

VEGETATION AREAS.

INTRODUCTION.

Having briefly described the vegetation regions of Ngamiland and Chobe (1932) and having recently travelled in the eastern

part of the Caprivi Strip, it is proposed to give an outline also of the flora in that territory.

As indicated by Shantz and Marbut (1923), the two dominant types of vegetation are, what they term:—

(a) Dry Forest, and
(b) Marsh Grass.

While Pole-Evans (1936), in his Memoir No. 15 on the vegetation of South Africa, would refer to Dry Forest as the Tropical Tree and Thorn Forest sub-division of Parkland, there is strictly speaking no corresponding equivalent for Marsh Grass, such as is encountered on flood plains. Possibly his best subdivision is Mixed Grass (7). Henkel (1931), in his Vegetation Types of Southern Rhodesia, would use the terms Open Forest (Tree Veld) and Grassland. Trapnell and Clothier (1937), in their ecological report on North-West Rhodesia, employ the more specific terms "Baikiaea-Copaifera and allied woodlands on central (*i.e.*, Central Kalahari) sands" and "Baikiaea forest and allied woodlands and Thicket on Transitional sands" for Dry Forest. For the Marshland Grass region the authors use the term "Alluvial flood plain and river valley grasslands". An investigation by a botanist is necessary to indicate the distribution of Trapnell and Clothier's subtypes in what is marked on the accompanying map as Deciduous Savannah.

All the authors mentioned have prepared excellent *coloured* charts to illustrate the situation and extent of the botanical regions they describe. It may be noted that of Pole-Evans' Evergreen and Deciduous Parkland, the major part of the vegetation is of the deciduous type.

In order to simplify the terminology it is proposed to refer to Dry Forest as Deciduous Savannah and to Marshland Grass according to whether the swamp conditions are:—

(a) Seasonal, or
(b) Permanent.

The map shows that approximately four-fifths of the country is covered with woodland or forest and that one-fifth is subject to flooding mainly by the Zambesi but also by the Kwando Rivers and that, there, grassland is dominant. It is convenient to describe Grassland first.

A. *Grassland* (Figs. 3 and 7).

Livingstone (1857) gives a good account of the nature of the terrain traversed by Oswell and himself when proceeding, in June, 1851, from Sebitwane's village (Old Linyanti) to Sesheke, which journey he estimated at 130 miles. Floods had apparently receded. He states: "The country over which we had travelled from the Chobe was perfectly flat, except where there were large anthills, or the remains of former ones, which had left mounds a few feet high. These were generally covered

with wild date trees and palmyras and in some parts there are forests of mimosae and mopani. *Occasionally* (8) the country between the Chobe and Zambesi is flooded, and there are large patches of swamps lying near the Chobe or on its banks" (p. 91). It was for the reason that inundation gave rise to luxuriant grazing that the Makololo, and subsequently the Barotse, were attracted to the Chobe Flats. Indeed it is stated that until the Germans occupied the Strip in 1909 the eastern part was the favourite grazing ground of Lewanika's herds.

The character of the Grassland is governed entirely by the duration and degree of flooding. Where it is (a) seasonal, the carrying capacity is better than that in the Deciduous Savannah area, which is dependent solely on summer rains. On the other hand, in or near (b) the permanent flood channels the grass is both dense and luxuriant. This is not due solely to the water, but also to the better quality of the soil, *i.e.*, the physical texture, for the nearer the river bank the richer the alluvium deposited.

Representatives of the families Gramineae and Cyperaceae in the above region are:—

(a) *Seasonal flooding*: *Hyparrhenia* spp., *Digitaria* spp., *Setaria* spp., *Eragrostis* spp., *Loudetia Hitchcockii*, *Imperata cylindrica* and *Elytrophorus africanus*.

Associated with these grasses are herbs, *e.g.*, *Momordica* sp., *Parinarium capense*, *Pachystigma* sp. (really a "Sunken tree"—Verdoorn, 1938), *Solanum panduraeforme*, etc.

(b) *Permanent flooding*: The swamp reed *Phragmites Mauritianus*, *Cyperus* spp., especially *C. papyrus*, *Scirpus corymbosus* and *Fuirena pubescens*.

Associated with these families are succulent herbs, *e.g.*, *Polygonum* spp. and water lilies (*Nymphaea* spp.).

About the periphery of the seasonally inundated area is Deciduous Savannah situated a few feet above the flood plain. Here and there, *e.g.*, on light sandy ridges, is an extension of *Terminalia sericea*. Where the soil is better, *Burkea africana* is a pioneer. The most striking example, however, of plant succession is to be seen along the motor track from Sheshe to Linyanti, where, owing to the cessation of seasonal flooding, the hitherto grassed flood plains have become invaded by *Acacia giraffae*. This phenomenon will be described under Woodland.

As indicated by Livingstone, the seasonally flooded plain is characterised by large mounds, originally constructed by termites. These are an important feature of the country, for during the period of inundation they constitute islands where habitations and gardens are safe from submersion. In the course of time they have acquired a covering of *evergreen* trees and are a conspicuous feature of the landscape. Indeed, so

many are there scattered about, that when gazing in any direction one invariably sees the horizon ringed by trees which grow *only* on the islands. (See Fig. 7.) An exception was seen east of Mumba on the Chobe Flats, where for miles there were but few mounds and trees (9).

B. *Woodland.*

The Deciduous Savannah of the grey Kalahari sand and the Evergreen trees on the mounds have been referred to; but a fuller account of Woodland must include evergreen trees along the river banks (or on islands in the Zambesi and Kwando Rivers) and the *Acacia giraffae* climax on ancient flood plains.

A summary of the position is:—

1. (a) Deciduous Savannah on unflooded Kalahari sand.
   (b) *Acacia giraffae* savannah climax on plains no longer flooded.
2. (a) Evergreen Mound Group of trees, *e.g., Garcinia Livingstonei,* and
   (b) Evergeen Fringing Forest on river banks.

The Evergreen trees have as constant factors the benefit of both the summer rains and river water.

1. *Deciduous Savannah* (Fig. 1).

It is obvious that the main difference between the environmental conditions of Deciduous and Evergreen woodland is the greater availability of water in the case of evergreen trees, together with, to a less extent, the better soil conditions. There are, of course, numerous individual exceptions, *e.g., Copaifera coleosperma* (Mazauri) retains its characteristic green leaves in Deciduous Savannah when everything around is bare, including *C. mopane.* Obviously owing to the deep sand many of the trees must have extensive tap roots, *Baikiaea plurijuga* (Rhodesian Teak) being well endowed in that respect. In point of fact it is remarkable how early in the season *Baikiaea* and *Brachystegia* acquire their leafy canopy. *Baikiaea* and *Pterocarpus angolensis* (Mukwa) are common trees along the Caprivi-Barotseland border and between Singalamwe and Lianshulu. Unfortunately, as recorded by Miller (1939), *Baikiaea* is "less hardy to fire than most of its associates" and accordingly its "prospects of survival as commercially valuable forest are poor". An excellent example of destruction was observed along the east bank of the Kwando (Mashi) River, where the Mafwe people, big cultivators of bush gardens in the transitional sands, destroy entire ridges of both Rhodesian teak and Mukwa (or Klaat, as it is better known in South Africa). Another species of Pterocarpus, *P. Stevensonii* (Mwangura), was also encountered, its many stems, with cream bark, being characteristic (10).

Where the sand was firm, notably near glades or stream beds which divide the low ridges, *Burkea africana* (Musheshe), was not only dominant, but was extending outwards and taking up the winding well-grassed bottoms. Owing to the method of growth, however, the grass cover is more abundant than is usually found in Deciduous Savannah. Termite mounds also occur in that type of country.

As indicated in the map, the dominant timber along the north bank of the Linyanti River is *Acacia*, especially *A. giraffae*. As explained in the botanical outline of Ngamiland and Chobe (Curson, 1932), the permanent marshland may, owing to diminishing water supply from a river, pass through the stages of (i) annual flooding and then (ii) occasional flooding to (iii) entire absence of inundation. Due to heavy rains, however, such an area may become flooded in the summer, but this state of affairs must not be compared with the flooding from a perennial stream.

It is interesting to note that Livingstone (1857) gave the latitude and longitude of the following points along the north bank of the Linyanti River:—

(i) Old Linyanti, latitude 18° 17′ 20″; longitude 23° 50′ 9″.

(ii) Sanshureh, latitude 18° 4′ 27″; longitude 24° 6′ 20″.

(iii) Island Mahonta, latitude 17° 58′; longitude 24° 6′.

(i) In regard to Old Linyanti in 1851 the town supported a population of "between six and seven thousand souls" (p. 178). It would appear that big changes have taken place regarding water and forest conditions in the neighbourhood during the past century. To-day flooding is absent and the dominant trees are *A. giraffae*, clearly part of the Sakapuka Forest as marked in the South African Air Force Caprivi compilation (1 : 250,000). Fig. 9, which was taken at Sheshe, gives an idea of the topography; but the position is in no way different from that previously described (Curson, 1932) and illustrated in the outline of the floral regions of Ngamiland and Chobe.

(ii) Sanshureh, when Livingstone was there in 1853, was an arm or channel flooded from the Kwando (Chobe) River and situated on the *south* bank of that river. According to the situation to-day, Sanshureh is north of the river, indicating that the river has changed its course towards the south.

According to the Native constables who accompanied me (notably Robert. and Josiah Mamili), the old course of the Linyanti meandered in an easterly direction (from its north-south direction) and was some 10—15 miles *north* of its present situation. Indeed it flowed eastwards just south of the present motor track, and a water course is still observable marking the old river bed.

Along the whole route at places where deep colluvial sand existed, *Terminalia sericea* (Mogonono) was seen, it being evident that the tree is a good pioneer.

(iii) When Livingstone was attempting to find the Chobe channel from the Sanshureh arm in 1853, he ultimately discovered an inlet and after paddling "from midday till sunset" (p. 177) he located the island Mahonta, on which a Makololo village—Moremi—was situated. The Natives were surprised at his crossing the river unperceived. Incidentally during his absence from his camp ten fine large oxen were bitten by *Glossina morsitans* and died. The wagons were taken to pieces and carried across the flood plain. Later, after "going about 30 *miles to the north*, in order to avoid the still flooded lands on the north of the Chobe", he turned westwards towards Linyanti (11).

It is clear from the accompanying map that Mahonta is now in camelthorn (*Acacia giraffae*) country and far from the Chobe.

Other characteristic trees of the Deciduous Savannah are *Afzelia quanzensis, Combretum Suluensis, Bauhinia Thorningii,* and the edible "fruit" trees *Sclerocarya caffra, Zizyphus mucronata, Adansonia digitata, Strychnos* spp. and *Parinarium mobola.* The finest specimen ever seen of *P. mobola* was at *Schuckmannsburg.* Among the Combretums it would appear, from Miss Verdoorn's knowledge of them, that one was the dwarf red blossomed *C. Oatesii.*

There are, of course, many grasses in the Deciduous Savannah, species of *Aristida, Heteropogon* and *Cymbopogon* being common.

2. *Evergreen Woodland* (Fig. 4).

The elevated areas, *i.e.*, the large mounds existing in the flood plain, are an important factor in the life of the people, for, whether of termite origin, or merely sandy ridges, they serve as village sites or even summer gardens (12). They vary in size from a few square yards to many acres in extent, and in elevation from a few feet to 15 feet. The soil varies from transitional sand to a grey sandy loam in the case of old termite mounds. Gluckman (1941) gives an illustration (Fig. 8) of "cattle *staked* on a mound to fertilise garden land near a Barotse homestead". While this was not observed in the Eastern Caprivi, the Natives nevertheless realise the value of manure because old cattle kraals are sometimes used for summer gardens.

As noted by Livingstone (1857), the mounds are covered with wild date trees (*Phoenix reclinata*) and palmyras (*Hyphaene* sp.), but the further west one proceeds, the less abundant they appear to be. The dominant trees of the mounds are

Ficus spp., *Kigelia pinnata, Lonchocarpus capassa, Trichilia emetica,* and the useful fruit-bearing trees *Diospyros mespiliformis* and *Garcinia Livingstonei.* Associated with these major shade trees are shrubs, *e.g., Grewia* spp., and grasses, *e.g., Chloris* spp. are common where sand is prevalent and *Cynodon dactylon* in all situations subject to trampling. Obviously where summer gardens are established there is clearing and burning of the smaller trees and shrubs and enclosures are made. With few exceptions all the small spring gardens, dependent on receded floodwater for germination, were enclosed, especially those containing tobacco.

Where the elevations are of Kalahari sand, their vegetable cover is a replica of the Deciduous Savannah, except that, owing to saturation in flood water for several months in the late summer, there is a greater availability of seepage water. Consequently not only are psammophilic trees evident, *e.g., Burkea africana, Strychnos* spp., *Terminalia* spp., but also hydrophytes, *e.g., Ficus* sp., *Trichilia* sp. and other evergreens.

The Fringing type of Evergreen forest is seen along rivers or permanent flood channels. All the evergreen broad-leafed species are represented, but *Syzygium guineense* and *Ficus* sp. are the commonest. (See Fig. 4.) The fringing trees may form a continuous avenue for some distance or be patchy in distribution. In any case they benefit directly from the river water, for further from the watercourse is and above high water level deciduous species predominate.

C. Floristic List of the Collection from the Eastern Caprivi Strip, October, 1945.

Potamogetonaceae:

Potamogeton nodosus Poir.—1080.

Gramineae:

Imperata cylindrica Beauv.—1163; 1216.
Trachypogon plumosus Nees.—1146.
Heteropogon contortus R. & S.—1085.
Vetiveria nigritana Stapf.—924; 931; 935; 1178; 1214.
Cymbopogon excavatus Stapf.—1000.
Hyparrhenia dissoluta (Nees.) Hubb.—1136.
H. sp. (*cf. H. rufa* Stapf.).—1012.
H. sp.—1147.
Themeda triandra Forsk.—1019.
Panicum (*cf. P. coloratum* L.).—1162.
P. sp.—1090.
Urochloa trichopus Stapf.—965.
Brachiaria sp.—1140.
Digitaria sp.—1142.
Tricholaena monachme Stapf. et Hubb.—1227.
Setaria (*cf. S. sphacelata* Stapf. et Hubb.).—1088.
Pennisetum typhoides Stapf. et Hubb.—1213.

Aristida meridionalis Henrard.—1233.
A. sp. (probably *A. diffusa* Trin.).—1138.
A. sp. (probably *A. graciliflora* Pilg.).—930; 1001; 1006; 1026; 1070; 1123; 1232; 1237; 1139.
Tristachya (probably *T. Eylesii* Stent and Rattray).—1122.
T. sp. (*cf. T. hispida* Schum.).—1137.
T. sp.—1020.
Loudetia sp. (*cf. L. Hitchcockii* Hubbard).—972.
Cynodon dactylon Pers.—1201.
Chloris gayana Kunth.—1089.
C. pycnothrix Trin.—964; 1054.
C. sp.—1238.
Eleusine indica (b.) Gaertn.—962; 1053.
Dactyloctenium (*cf. D. geminatum* Hack.).—1210.
Triraphis sp.—949.
Elytrophorus africanus Schweik.—1133.
Phragmites mauritianus Kunth.—1234.
Eragrostis superba Peyr.—1161; 1230.
E. sp. (*cf. E. gangetica* Steud.).—1217.
E. sp. (*probably E. gangetica* Steud.).—1221.
E. sp. (*cf. E. lappula* Nees.).—1004.
E. sp. (*cf. E. lehmanniana* Nees.).—1160.
E. sp.—995.
E. sp.—1227.
Pogonarthria sp. (*cf. P. orthoclada* Peter.).—1254.

Cyperaceae:

Cyperus haspan L.—1158; 1169; 1200; 1225.
C. papyrus L.—1021.
C. sphaerospermus Schrad.—1003.
Pycreus rehmannianus C. B. Clarke.—1224.
Ficinia (near *F. lateralis* (Vahl.) Kunth.—1131.
Fuirena leptostachya Oliv.—1144; 1159; 1226.
Scirpus corymbosus Roth.—1068; 1129; 1231.
S. nodosus Rottb.—1002.
Fimbristylis sp. (near *F. miliacea* Vahl.).—1145.

Palmae:

Hyphaene sp.—1128.

Commelinaceae:

Pollia sp. (aff. *P. Mannii* C. B. Cl).—1248.

Liliaceae:

Anthericum sp. (aff. *A. elongatum* Willd.).—1164.
Aloe sp. (*A. maculatae*).—1151.
A. sp.—No number.
Albuca sp. (aff. *A. Bainesii* Baker).—1101; 1112.
Scilla sp. (aff. *S. neglecta* van der Merwe).—1102; 1124.
Ornithogalum sp. (near *O. pretoriense* Baker).—1072.

Sansevieria aethiopica Thunb.—1061; 1100.
Asparagus Cooperi Baker.—1212.
A. racemosus Willd.—900.

Moraceae:
Ficus Burkei Miq.—993.

Olacaceae:
Ximenia americana L.—1205.

Polygonaceae:
Polygonum glutinosum Meisn.—1126; 1228.
P. sp.—1249.

Amarantaceae:
Amarantus spinosus L.—961.
A. Thunbergii Moq.—1045.
Aerva sp. (*cf. A. leucura* (L.) Moq.).—960.
Achyranthes aspera L.—1180.

Nyctaginaceae:
Commicarpus plumbagineus (Cav.) Steud.—1171.

Phytolaccaceae:
Lophiocarpus Burchellii Hook f.—1119.

Aizoaceae:
Mollugo cerviana Ser.—1040.
Glinus lotoides L.—1052.

Caryophyllaceae:
Pollichia campestris Soland.—981; 1039; 1079.

Nymphaeaceae:
Nymphaea sp.—1067; 1130.

Menispermaceae:
Cocculus hirsutus (L.) Diels.—1175.
Cissampelos mucronata A. Rich.—1048.

Capparidaceae:
Capparis tomentosa Lam.—943; 973; 1181; 1229.
Boscia Pechuelii Kuntze.—958; 1206.

Rosaceae:
Parinarium mobola Oliver.—1032.

Leguminosae:
Albizzia versicolor Welw.—940.
Acacia albida Delile.—1185.
A. pallens (Benth.) Rolfe.—1182.
A. Woodii Burt-Davy.—1183; 1236.
A. sp. (possibly *A. campylacantha* Hochst.)—1174.
Dichrostachys glomerata (Forsk.) Hutch. et Daly.—1156; 1199.
Amblygonocarpus obtusangulus Harms.—974.
Brachystegia sp. (compares closely with *B. dulcis* Hutch. et Burt-Davy).—910.

Afzelia cuanzensis Burtt-Davy.—913.
Bauhinia macrantha Oliv.—916.
B. Thonningii Schum.—1018.
Dialium Simii Phillips.—942.
Peltophorum africanum Sond.—979.
Baphia obovata Schinz.—945; 1027.
Indigofera candicans Ait.—919.
I. flavicans Baker (aff. *I. diphylla* Vent.).—229; 998.
I. hololeuca Benth.—1149; 1202.
Tephrosia amoena Forbes.—1121.
Sesbania aegyptiaca Pers.—934.
S. Rogersii Phillips et Hutch.—922.
(*Dalbergia armata* E. Mey.).—1031.
Pterocarpus angolensis D.C.—967; 975.
Lonchocarpus capassa Rolfe.—928; 1222.
Rhynchosia minima D.C.—1220.

Linaceae:
Linum usitatissimum L.—948.

Zygophyllaceae:
Tribulus sp.—951.

Meliaceae:
Trichilia emetica Vahl.—1017; 1184.

Polygalaceae:
Securidaca longipedunculata Fresen. var. *parvifolia* Oliver. —977.

Euphorbiaceae:
Antidesma venosum E. Mey.—909.
Croton megalobotrys Müll. Arg.—1116; 1186; 1192; 1198.
C. Menyhartii Pax.—902; 918; 970.
Ricinus communis L.—1207.
Euphorbia sp. (affinis *E. prostrata* Ait.).—915.
E. hirta L.—966.
Ricinodendron Rautanenii Müll. Arg.

Anacardiaceae:
Sclerocarya caffra. Sond.—1115.
Rhus pyroides Burch. var. *gracilis* (Engl.) Burtt-Davy.—1023; 1120.

Hippocrateaceae:
Hippocratea obtusifolia Roxb.—917.

Vitaceae:
Cissus sp.—903.

Tiliaceae:
Grewia retinervis Burnet.—1094; 1177.
Triumfetta sp. (probably *T. pilosa* Roth.).—1245.

Malvaceae:

Abutilon angulatum Mast.—1035; 1093.

= J. Borle. 315 ex Livingstone and C. E. F. Allen, 420 ex Victoria Falls.

Sida cordifolia L.—929; 947.

S. rhombifolia L.—921; 996.

Pavonia sp. (affinis *P. Baumii* Gürke.).—990; 1216; 1223.

Hibiscus micranthus L.—905.

H. sp. (affinis *H. linearifolius* Willd.).—963.

Gossypium transvaalense Watt.—1209.

Sterculiaceae:

Melhania ferruginea A. Rich.—1098.

Hermannia boraginiflora Hook.—1239.

H. sp. (affinis *H. boraginiflora* Hook.).—1203.

Guttiferae:

Garcinia Livingstonei T. Anders.—936; 1241.

Elatinaceae:

Bergia decumbens Planch.—1025.

Flacourtiaceae:

Homalium subsuperum Sprague.—969.

Lythraceae:

Rotala sp. (*cf. R. tenella* Hiern.).—1013.

= Mogg 15492 ex Victoria Falls.

Ammannia senegalensis Lam. var. *multifida* Roxb.—1132.

= Schoenfelder 819, ex S.W.A. et Dinter 7347 ex Grootfontein, S.W.A.

Nesaea mucronata Koehne.—1014; 1172.

Combretaceae:

Combretum apiculatum Sond.—100; 395; 569.

C. coriaceum Schinz.—329.

C. suluense Engl. et Diels.—968.

C. transvaalense Schinz.—114; 941; 992.

C. transvaalense Schinz. var. *villosissimum* Burtt-Davy.—1071; 1191.

C. ukambense Engl.—1117.

= Schoenfelder S. 171 ex Okavango.

C. sp. (affinis *C. cataractarum* Diels.).—1069; 1109.

= Schoenfelder 182.a ex Kibwezi.

C. sp. (affinis *C. mechowianum* O. Hoffm.).—811.

C. sp.—957.

Myrtaceae:

Syzygium guineense (Willd.) D.C.—914; 971; 1244.

Halorrhagidaceae:

Myriophyllum spicatum L.—933.

Umbelliferae:

Centella sp. (affinis *C. asiatica* L.) Urb.—1242.

Sapotaceae:

Mimusops Zeyheri Sond.——1250.

Ebenaceae:

Royena decidua Burch.—1193.
Euclea lanceolata E. May.—1108.

Oleaceae:

Jasminum mauritianum Bojer.—1024.

Apocyinaceae:

Carissa edulis Vahl.—1134.
Vinca minor L.—938.
Strophanthus sp. (affinis *S. hispidus* D.C.).—1030.

Asclepiadaceae:

Schizoglossum aciculare N. E. Br.—1247.
S. sp.—1251.
Asclepias sp.—unmatched in National Herbarium and apparently undescribed.—1154.
Orthanthera jasminiflora N. E. Br.—1243.

Convolvulaceae:

(affinis *Seddera suffructicosa* (Schinz.) Hall. f.).—1097.
Jacquemontia capitata G. Don.—955.
Ipomoea angustifolia Jacq.—1042.
I. obscura Ker.—1008.
I. shirambensis Baker.—908.

Borraginaceae:

Cordia ovalis R. Br.—1252.
Heliotropium ovalifolium Forsk.—1197.
H. sp.939;
= M. Mücke 3 ex Trop. Africa, unmatched in National Herbarium, Pretoria.

Verbenaceae:

Lantana salvifolia Jacq.—1084; 1240.
Lippia nodiflora Michx.—1077.
Vitex Hildebrandtii Vatke.—952.
Clerodendron simile Pearson.—991.
C. spinescens Gürke.—988.
C. sp.—976.

Labiatae:

Acrotome inflata Benth.—1103.
A. sp.—904.
Leonotis sp.—999.
Hyptis pectinatus Poit.—1062; 1081; 1110.
Ocimum sp. (possibly *O. americanum* L.).—1211.

Solanaceae:

Solanum panduraeforme E. Mey.—959; 987; 1092.

Scrophulariaceae:

Sutera pristisepala Hiern.—1235.
Alectra orobanchoides Benth.—989.
Rhamphicarpa fistulosa Benth.—1170.
R. tubulosa Benth.—901; 1155; 1173.

Bignoniaceae:

Spathodea sp. (affinis *S. nilotica* Seem.).—937; 944.

Pedaliaceae:

Sesamum angustifolium Engl.—920; 1005; 1056.
S. sp. (possibly *S. capense* Burm.).—1208.

Acanthaceae:

Thunbergia dregeana Nees.—953; 1055.
Phaulopsis parviflora Willd.—1073;
= H. K. Munro P. S. 210.
(*Sclerochiton* sp.).—1086.
Blepharis sp. (affinis *B. longiflora* Lindau).—984; 1187.
Hypoestes aristata R. Br.—1046.
H. verticillaris R. Br.—1083.
Justicia pulegioides E. Mey.—1016.

Rubiaceae:

Crossopteryx febrifuga Benth.—1253.
Gardonia spathulifolia Stapf.—978.
Rhabdostigma sp.—954.

Cucurbitaceae:

Momordica balsamina L.—1125; 1218.
Citruilus naudinianus (Sond.). Hook.—1176.

Campanulaceae:

Lobelia resulata sp. Moore.—1104; 1167.
L. sp.—1127.
= Mme. J. Borle 239 ex Barotseland.

Compositae:

Ethulia conyzoides L.—1076; 1082.
Erlangea sp. (affinis *E. misera* O. Hoffm.).—946; 1038; 1047; 1063.
Erigeron sp. (probably *E. linifolius* Willd.).—1095.
Nidorella sp. (probably *N. resedifolia* D. C.).—1043; 1044.
Blumea gariepina D. C.—925.
Pluchea Leubnitziae (O. Hoffm.) N. E. B.—1066; 1074; 1099; 1153; 1168.
Nicolasia sp. (affinis *N. felicioides* (Hiern.). sp. Moore.—1195.
Epaltes gariepina Steetz.—1064; 1087; 1157; 1215.
Sphaeranthus sp. (affinis *S. peduncularis* D. C.).—907.
Gnaphalium luteoalbum L.—1135; 1246.
G. sp. (probably *G. undulatum* L.).—1059.

Helichrysum argyrosphaerum D. C.—1050.

H. leptolepis D. C.—1165; 1190.

H. Seineri Moeser.—1029; 1196.

Galinsoga parviflora Cav.—1051.

Dicoma capensis Less.—1166;

= Mogg 8954 ex Vryburg; and Burtt-Davy 14,000 ex Takoon.

Sonchus sp. (probably *S. oleraceus* L.).—1105.

(Genera Ignota (a)—932; 1111.)

(Genera Ignota (b)—956.)

CONCLUSIONS.

Although it is a quarter of a century since Schwarz (1919) drew attention to the importance of the Kalahari Region in relation to the desiccation of the sub-continent, no systematic study has yet been undertaken of that territory.

Among the many brief surveys (Rey, C. F., 1932) is that described in the preceding pages. The main conclusions are:—

1. The Eastern Caprivi Strip, although only a very small part of the Kalahari, is nevertheless important because of its relationship to the Zambesi and Kwando Rivers.
2. The area, approximately 4,500 square miles in extent, supports a Native population of 12,000 souls and 26,000 head of cattle.
3. Four-fifths of its surface of grey transitional sand is covered with deciduous woodland which receives only summer rains. The remaining one-fifth, the eastern extremity, is flooded between January and June each year and as a result grassland is dominant.
4. The general altitude is just over 3,000 feet, the dry, unflooded portion being slightly higher than the seasonally flooded area at the confluence of the Zambesi and Kwando Rivers.
5. The Eastern Caprivi Strip falls within the 25 to 30 inches rainfall region as determined by the records at Katima Mulilo and Kasane.
6. The soil comprises alluvium (sandy loam) chiefly along the Zambesi and Kwando valleys, and a grey sand away from the rivers.
7. The agricultural potentiality (Shantz and Marbut) of the soil varies, from the alluvium which is fair to good, to the grey sand, which is poor to fair.
8. The grazing likewise varies from the alluvium, where the pasturage is good, to the sandveld, where it is poor to fair.
9. The forests, chiefly Rhodesian teak, are patchy and best developed in the north-west corner of the territory.

10. The flora, of which a small collection was made, is typical of the Northern Kalahari. The carrying capacity for livestock is greatest along the rivers, especially on the Chobe flats, and lowest in the deciduous woodland.
11. In spite of the small human and livestock "populations", and the relative absence of "run-off", changes indicating desiccation are taking place. A comparison of data furnished by Livingstone (who also reported progressive desiccation—1857, p. 54) with the position to-day supports this view.
12. Areas formerly subject to seasonal flooding are no longer inundated and as in the vicinity of Lake Ngami, an *Acacia giraffae* climax has replaced the former grassland.
13. Little is known of the hydrology of the Zambesi and the Kwando Rivers, especially of the latter, and much is to be learned of flow, analysis, waterlogging and "brak" of irrigable soil, etc.
14. In spite of tropical conditions, *e.g.*, excessive heat, malaria, etc., the health of the inhabitants is good, owing chiefly to an abundant supply of cow's milk.
15. A plan for the Sub-continent is imperative, especially the Kalahari Region, where the potentialities are vast.

NOTES.

(1) Count Caprivi was German Foreign Secretary at the time the territory was ceded to Germany, namely 1890. According to Hole (1926), "the date of the cession of Barotseland to Great Britain (27.6.1890) . . . anticipated by four days only the signing of the Anglo-German agreement. It was also executed prior to the Anglo-Portuguese agreement which assigned to Portugal everything west of the Zambesi, but this, as we know, was rejected by the Cortes, which thereby gave Rhodes the chance of reasserting Lewanika's rights up to 22° E. Long."

(2) *Vide* Notes on the Flora of Ngamiland and Chobe (1932), 18th Report, Director of Veterinary Services and Animal Husbandry, Onderstepoort.

(3) In a discussion on 27th October, 1945, at Kasane.

(4) Capt. C. E. Kruger. The value of the figures is relative since low-water level varies from year to year.

(5) While scientists must be appreciative of the fact that some records are available, yet the lack of knowledge in regard to desiccation generally in Africa, and in the Kalahari in particular, is such that all Governments should establish efficient meteorological stations where facilities exist.

(6) Although Kasane is in Bechuanaland Protectorate, it is situated on the South Bank of the Chobe and is separated from Caprivi by probably 100 yards.

(7) It is interesting to note how two authorities such as Shantz and Pole-Evans vary in their interpretation of the savannah east of the Drakensberg in the Eastern Transvaal and in the Northern Transvaal. The former describes the country as "Acacia-Tall Grass Savannah" and the latter refers to it as "Evergreen and Deciduous Tree and Thorn Forest". The one is influenced by the grass growth and the other by the relative abundance of woodland.

(8) Not italicised in original. It is strange he should have said this. At any rate in 1853 he experienced great difficulty in crossing the flooded Chobe.

(9) This is probably related to a change in the underlying geology and the derived soils which are unsuitable to termites.

(10) Miller (1939) also notes that "The forest of the Chobe sand sheet (*i.e.*, west bank of Zambesi) is considerably younger than that on the opposite bank of the Zambesi".

(11) Two points arise which it would be interesting to clear up; these are: (a) At what date did the people move from Old Linyanti, and was it to the present site? (b) Constable Robert stated that Sebitwane was buried near Sheshe, just south of the motor track. Why was this site selected?

Captain C. E. Kruger, Magistrate at Katima Mulilo, has been able to trace a place, Mahundu, about 18 miles east of Livingstone's Mahonta and he knows of the Shuara waterway. Whether this is related to Livingstone's Sanshureh is not clear—(letter 1/1/2 of 9.1.46).

(12) Gluckman (1941) in his *Economy of the Central Barotse Plain* indicates the part played by the mound in Barotse life, *e.g.*, he says: "Mounds, as the building land, therefore had far greater integrating value in the social organisation than any other type of land" (p. 28). Their relative position in Masubia life has still to be investigated.

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PHOTOGRAPHS.

Fig. 1. *Typical deciduous forest*, chiefly *Copaifera, Burkea, Strychnos, Baikiaea* and *Terminalia*, seen in 4/5ths of territory, is dependent only on summer rainfall. Although it is 25.10.45 leaves are only evident in a few species, *e.g.*, *Ricinodendron*. The grass cover is usually sparse and burned by wandering Bushmen in winter.

Fig. 2. A view south of Ihaha Drift (Caprivi Bank) of the Kasane brown sand plateau in Bechuanaland Protectorate. The motor lorry is on a W.N.L.A. pontoon. *The trees nearest the water are evergreen, e.g., Lonchocarpus* and *Garcinia*, while those

on the plateau are deciduous. Note the luxuriant swamp vegetation, especially *Phragmites.*

Fig. 3. A close view of an island or mound on which the vegetation has been felled and burned for cultivation as soon as the rains permit. 26.10.45.

Fig. 4. *Grassland of seasonally flooded Chobe flats* from sand ridge on which Kabuta Village stands. Along banks of Chobe River are evergreen trees, notably *Syzygium.* In the distance is Kasane Plateau, about 100ft. high. *Terminalia,* a deciduous tree, frequently grows on such sand "islands". 26.10.45.

Fig. 5. Linyanti (Chobe) River at Parakarunga. It is generally stated that the Zambesi River washes back along the Chobe as far west as north of the vicinity of Kachikau. It is further evident that the Chobe at Parakarunga breaks south, causing water logging. (Photo. by Mr. D. F. Kokot, 19.6.44.)

Fig. 6. The confluence of the Zambesi and Chobe Rivers at Old Kazungula. Impalila Island on the left. (Photo. by Mr. D. F. Kokot.)

Fig. 7. Grassland which is seasonally flooded except for the *"islands", on which grow evergreen trees.* Owing to the abundance of "islands", a glance in any direction gives the impression that the horizon is ringed with trees.

Fig. 8. *Group of Mayeyi people* near Sangwali's Village (Sheshe). 18.10.45. Mr. Rhodes and Native staff at back. Livingstone (1857) stated (p. 64) that the "Bakoba or Makuba of Ngamiland call themselves Bayeye (i.e., men), but the Bechuanas call them Bakoba" or slaves.

Fig. 9. *Red and white Sanga bull* with upright, lyre-shaped horns with circular base. Value £5. For the first half of the year the cattle live under "desert" conditions and for the second half graze on fluke-infested, seasonally flooded grassland.

Fig. 10. *Black and white Sanga cow.* The grass rope through the nasal cartilage is for restraint. Value £4—£5. The general condition of all cattle in October before the rains is far better than that of Native cattle in the Union before the summer rains. Note conformation, well-developed dewlap, anterior hump, pronounced navel fold and long tail characterising the type.

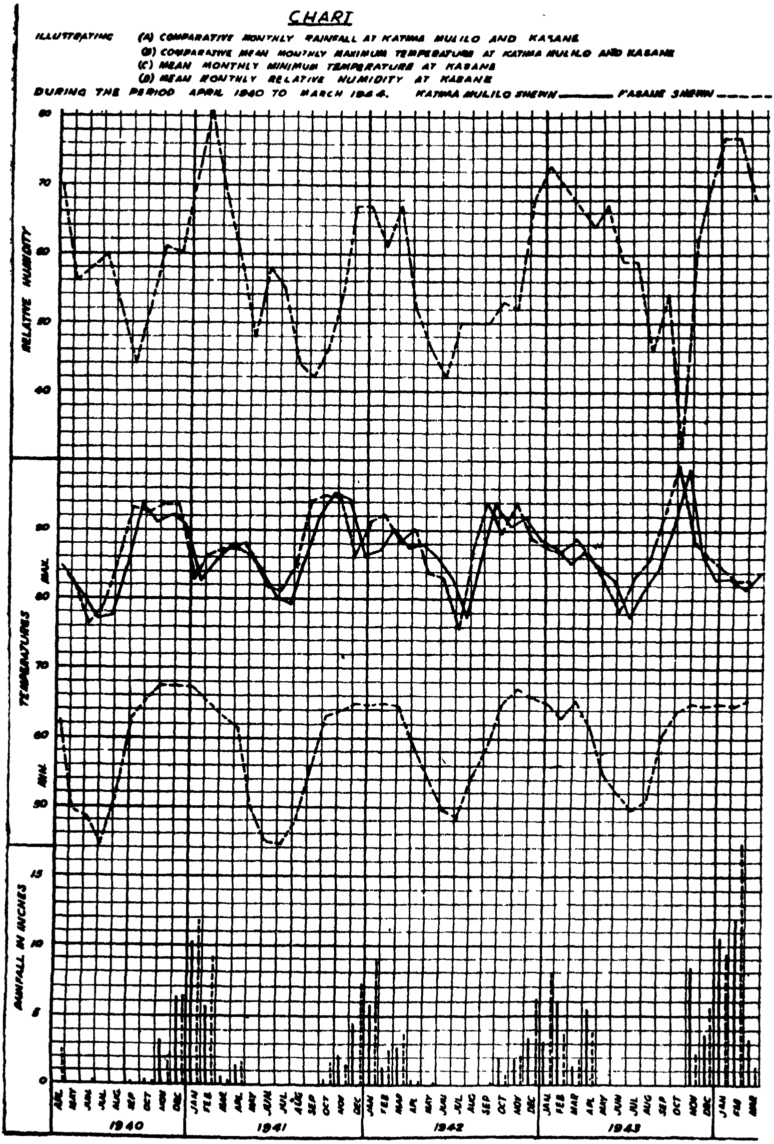
CHART
ILLUSTRATING (A) COMPARATIVE MONTHLY RAINFALL AT KATIMA MULILO AND KASANE
(B) COMPARATIVE MEAN MONTHLY MAXIMUM TEMPERATURE AT KATIMA MULILO AND KASANE
(C) MEAN MONTHLY MINIMUM TEMPERATURE AT KASANE
(D) MEAN MONTHLY RELATIVE HUMIDITY AT KASANE
DURING THE PERIOD APRIL 1940 TO MARCH 1944. KATIMA MULILO SHEWN ——— KASANE SHEWN - - - -
RELATIVE HUMIDITY
TEMPERATURES
MAX.
MIN.
RAINFALL IN INCHES
1940
1941
1942
1943

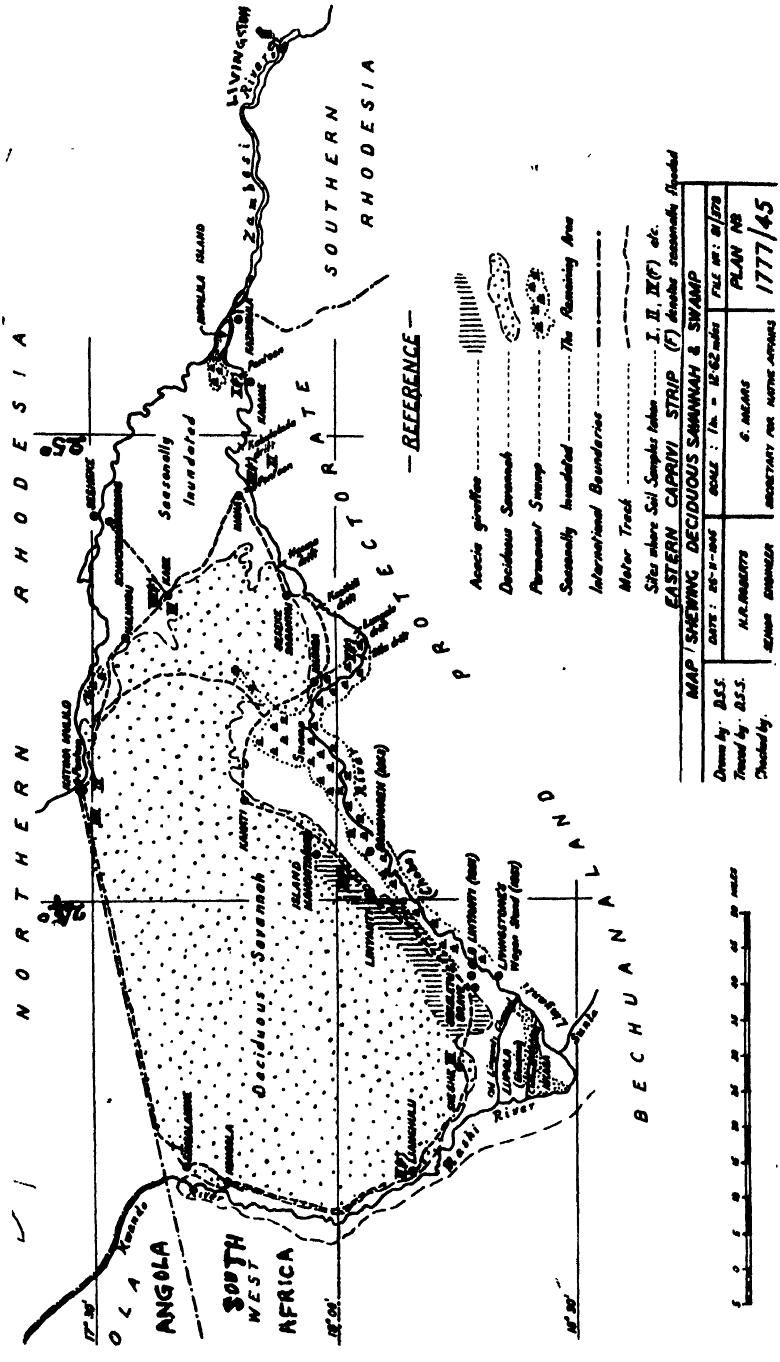
NORTHERN RHODESIA
SOUTHERN RHODESIA
BECHUANALAND PROTECTORATE
ANGOLA
SOUTH WEST AFRICA
LIVINGSTONE
Zambesi River
Kwando
Chobe
Seasonally Inundated
Deciduous Savannah
— REFERENCE —
Acacia giraffae
Deciduous Savannah
Permanent Swamp
Seasonally Inundated — The Remaining Area
International Boundaries
Motor Track
Sites where Soil Samples taken — I, II, III(F) etc. (F) denotes seasonally flooded
EASTERN CAPRIVI STRIP
MAP SHEWING DECIDUOUS SAVANNAH & SWAMP
Drawn by: D.S.S.
Traced by: D.S.S.
Checked by.
SCALE: 1 in. = 12.62 miles
PLAN No
1777/45


FIG. 1


FIG. 2


FIG. 3

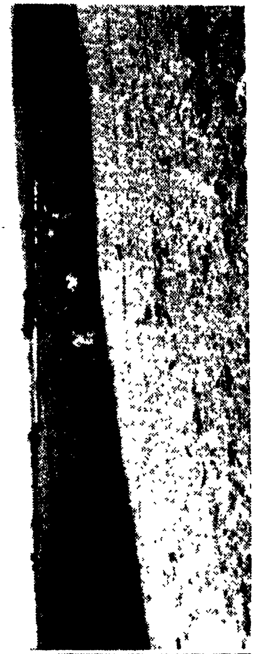
FIG. 4

FIG.5

FIG.6

FIG. 8

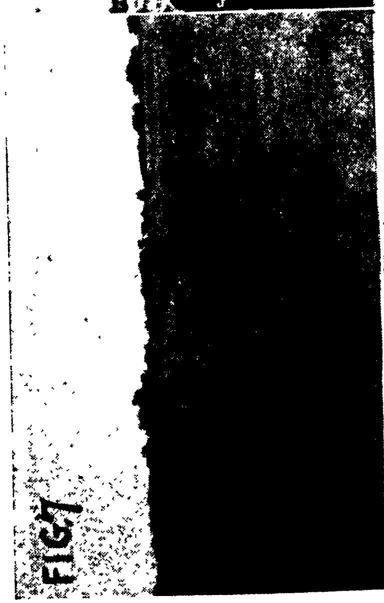

FIG. 7

FIG. 10

FIG. 9

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 158-166, July, 1947.*

ABNORMAL FEMALE GAMETOPHYTES IN RELATION WITH POLYEMBRYONIC SEEDS IN UPLAND COTTON

BY

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Read 3rd July, 1946.

Since polyembryonic seeds in cotton were first referred to by Harland in 1936, other cases of twinning have been found in this genus (Silow and Stephens, 1944). The occurrence of polyembryonic seeds seems to be particularly frequent in amphi-tetraploid cultivated American species of cotton (*G. barbadensis* and *G. hirsutum*).

In almost every case investigated, one of the twins was a normal diploid, the other being a haploid, a more or less sterile plant.

The occurrence of such cases of heterogeneous twins has been explained by the formation of two embyro sacs in the same ovule, one of them being fertilised and the other developing parthenogenetically.

During our studies on the development of the embryo sac in a variety of Upland cotton (9L36) we had the opportunity of finding two abnormal cases which could easily explain the formation of heterogeneous twins. But in neither of these two cases was it a question of a double embryo in the same ovule.

Development of the embryo sac in cotton follows what is known as the normal type (Gore, 1935). A megaspore mother cell by two successive reduction divisions gives rise to four megaspores; the three micropilar ones degenerate while the chalazal megaspore develops in the embryo sac. By three successive divisions eight nuclei are formed, *i.e.*, the egg-cell, the two synergid cells, the two polar nuclei and the three antipodal cells. These antipodal cells degenerate very early in cotton—about three or four days before the anthesis; therefore, the mature embryo sac is composed, before fertilization, of only five nuclei; viz., one egg-cell, two synergid-cells and two polar nuclei.

When the pollen tube enters the embryo sac the two male nuclei fuse, one with the egg-cell, the other with the two polar nuclei. The embryo develops from the fertilized egg-cell, the endosperm from the triploid nucleus resulting from the fusion of one male nucleus with the two polar nuclei.

The first abnormal embryo sac (Text Fig. 1 and Plat. I and II) was fixed on the day of the anthesis at eight o'clock in the morning, before fertilization. The ovule was normal in appear-

ance but it contained ten nuclei instead of five: two egg-cells, four synergid-cells and four polar nuclei. The antipodal cells must have been six, but they must have degenerated as usual, long before fertilization.

The second abnormal embryo sac (Text Fig. 2 and Plat. III and IV) was fixed on the first day after the anthesis at three o'clock in the afternoon, after fertilization took place. This embryo sac must have had the same constitution as the preceding one: two egg-cells, four synergid-cells, four polar nuclei and six antipodal cells. When the two male nuclei entered the embryo sac, one must have fused with one of the egg-cells, the other with one pair of polar nuclei. This triploid endosperm mother cell began at once to divide, as usual, and when the ovule had been fixed, we got: one fertilized and one unfertilized egg-cell; two normal synergid-cells and two others digested by the entrance of the pollen tube, as usually occurs; one pair of polar nuclei not yet fused, and the two first nuclei originated by the division of the endosperm mother cell.

If this ovule had continued to develop it would probably have given rise to a polyembryonic seed, the fertilized embryo producing a normal diploid plant, and the unfertilized egg-cell originating parthogenetically a haploid plant.

The finding of these two stages of development of the embryo sac is in complete agreement with the occurrence of heterogeneous twins in cotton, and gives a thoroughly cytological interpretation of these particular cases of twinning.

On the other hand, the occurrence of this anomaly does not seem to be very rare since we found it twice in a few hundred ovules studied.

Harland, as well as Silow and Stephens, attributed the origin of heterogeneous twin plants in cotton to the formation of two embryo sacs in the same ovule, one of them fertilized and the other developing parthenogenetically. If two embryo sacs were formed in the same ovule by the development of two megaspores they would be as independent of each other as two cells of different origin. This is not our present case. Here we are in the presence of a single embryo sac with sixteen nuclei instead of eight.

How could such an embryo sac have originated? Theoretically three origins are possible:—

(a) After the reduction division of the megaspore mother cell and the degeneration of the three micropolar megaspores, the fourth megaspore divided four times instead of three and so gave rise to an embryo sac with sixteen cells instead of eight. This would be a modification of the normal type with an extra nuclear division (Schnarf, 1936).

(b) After the reduction division of the megaspore mother cell, only two of the four nuclei thus formed degenerated; the two remaining nuclei divided three times instead of two, thus originating an embryo-sac with sixteen nuclei. This would be a modification of the Scilla-type with an extra nuclear division.

(c) None of the four megaspore nuclei degenerated; they divided twice again and gave rise to a sixteen nucleated embryo sac with two egg-cells, four synergid-cells, six antipodal cells, and four polar nuclei.

This would correspond to the Peperomia-type with a different distribution of the functions of the cells, *i.e.*, with the differentiation of only two egg-cells.

If the development of the embryo-sac in cotton follows the normal type, the abnormal cases now found are more easily explained by the first hypothesis, *i.e.*, degeneration of three megaspore cells followed by four nuclear divisions of the remaining megaspores.

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*Original paper not seen.

FIGURES AND PLATES—EXPLANATION.

Fig. 1.—Schematic reconstitution of abnormal embryo-sac No. 1, before fertilisation:

1 and 2: the two egg-cells.

3, 4, 5, and 6: the four synergid-cells.

7, 8, 9, and 10: the four polar nuclei.

At the chalazal end the six degenerated antipodal cells which must have disappeared a long time before the ovule has been fixed.

Fig. 2.—Schematic reconstitution of abnormal embryo-sac No. 2, after fertilisation:

1: fertilized egg-cell.

2: unfertilized egg-cell.

3 and 4: the two living synergid-cells.

5 and 6: the two degenerated and digested synergid-cells.

7 and 8: the two not yet fused polar nuclei.

9 and 10: the two first nuclei of the endosperm.

At the chalazal top the six assumed antipodal cells degenerated long time before.

Plates I and II:

Different sections showing the constitution of an abnormal embryo-sac before fertilization.

Figs. 1, 3, 5, 7, 9: Sections of the ovule (10 μ thick, $\times$ 50).

Figs. 2, 4, 6, 8, 10: The same sections ($\times$ 230).

Nos. 1 and 2: the two egg-cells.

Nos. 3, 4, 5 and 6: the four synergid-cells.

Nos. 7, 8, 9 and 10: the four polar nuclei.

Plates III and IV:

Sections of the second abnormal embryo-sac fixed after fertilization (20 μ thick, 1, 3, 5, 7, $\times$ 50; 2, 4, 6, 8, $\times$ 230).

No. 1 (Figs. 1 and 2): the fertilised egg-cell.

No. 2 (Figs. 3 and 4): thė unfertilized egg-cell.

No. 3 (Figs. 5 and 6) and No. 4 (Figs. 7 and 8): the two living synergid-cells.

Nos. 5 and 6 (Figs. 7 and 8): the two degenerated synergid-cells.

Nos. 7 and 8 (Figs. 3 and 4): the two not fused polar nuclei.

No. 9 (Figs. 5 and 6) and No. 10 (Figs. 1 and 2): the two nuclei resulting from the first division of the triploid endosperm mother-cell.

Material fixed in alcohol-formol-acetic acid, embedded in paraffin, stained in iron haematoxylin—light green.

FIG. 2.

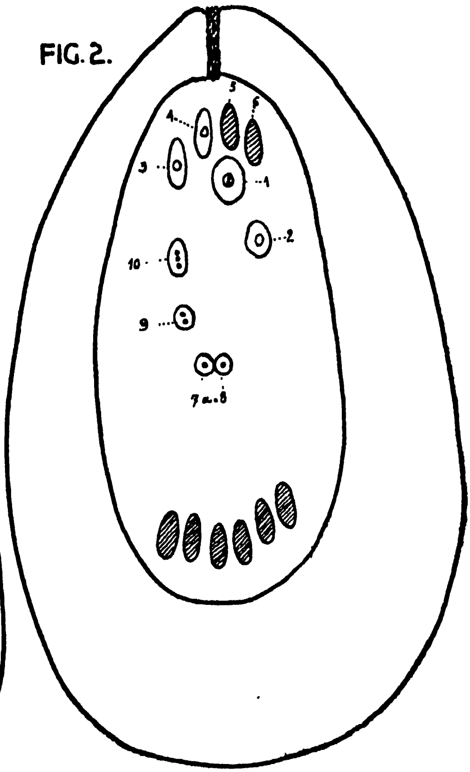
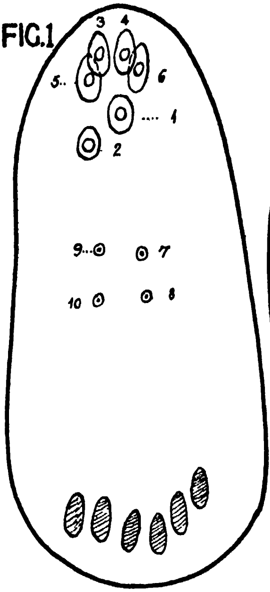
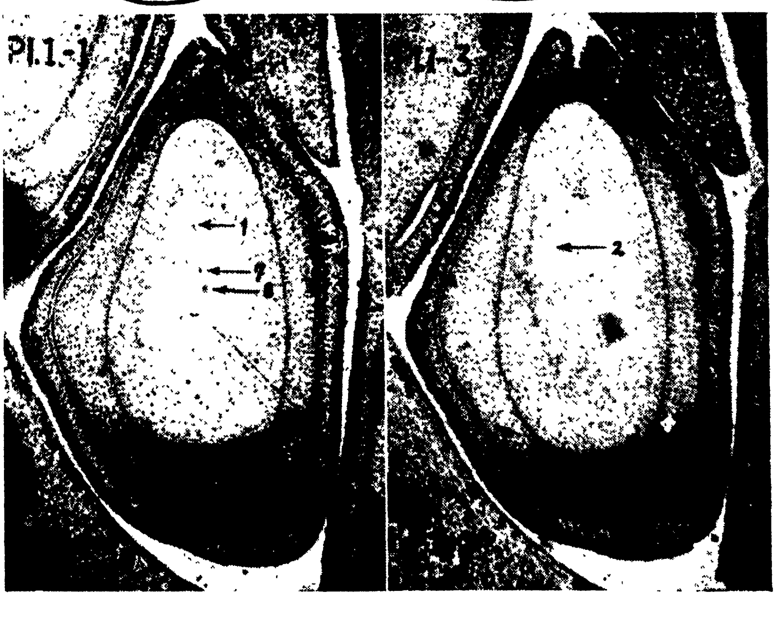
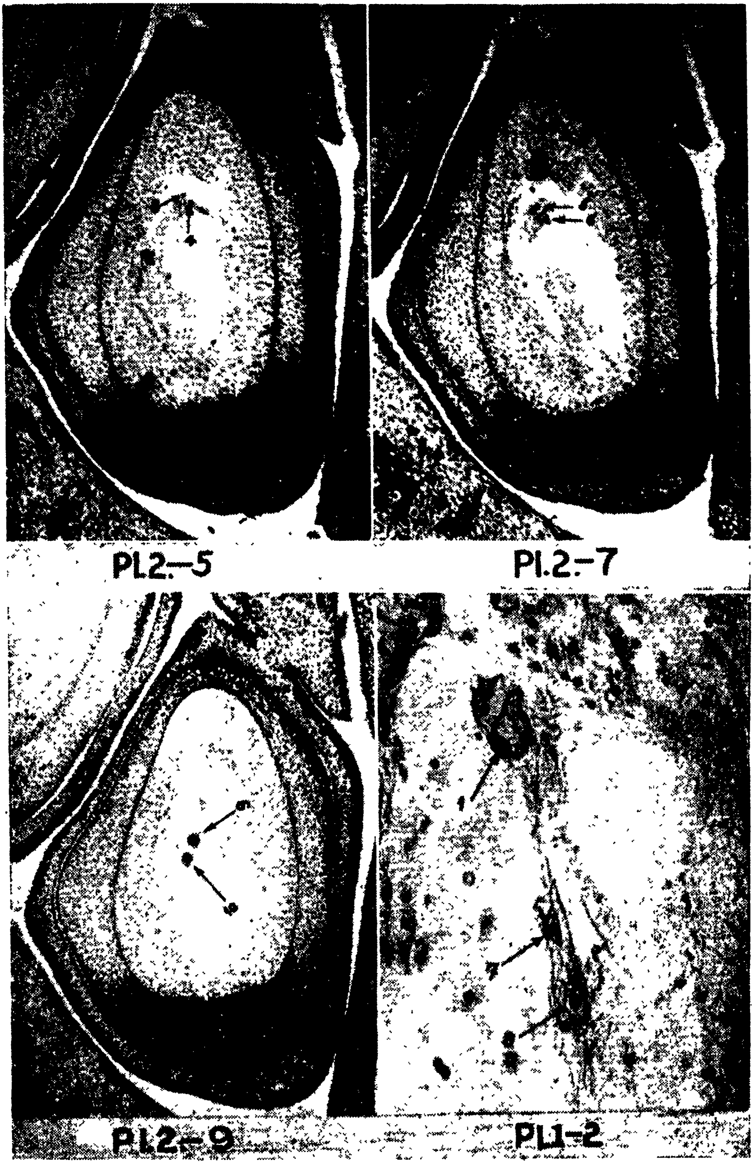
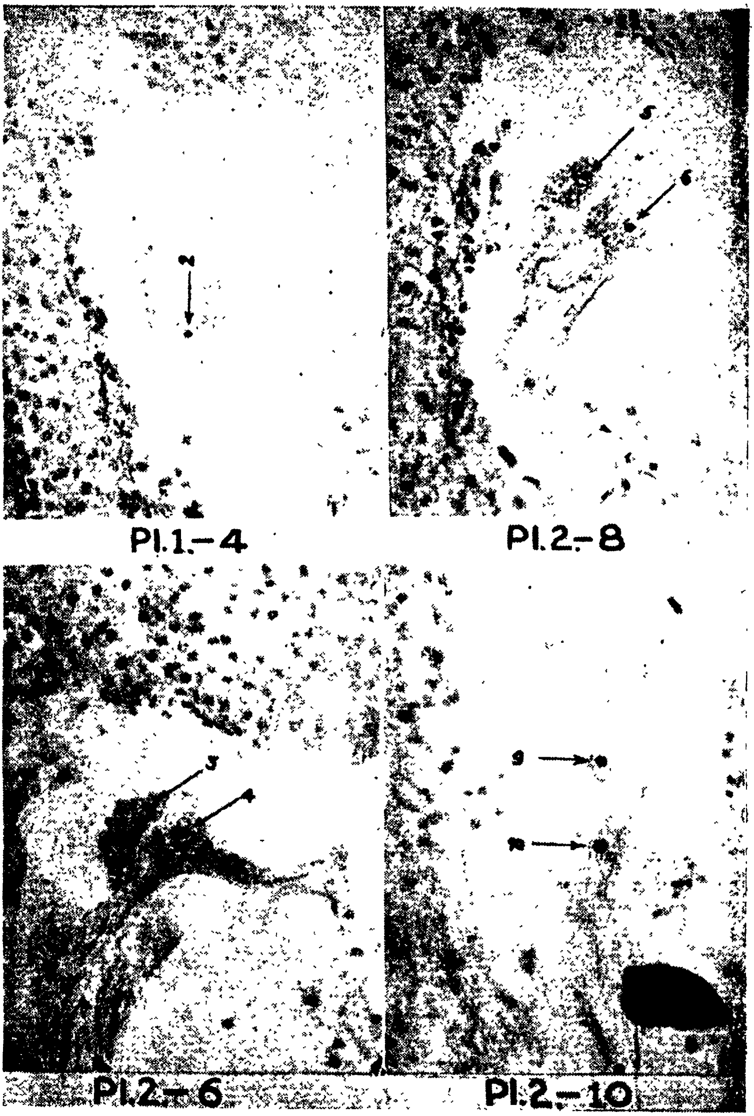


FIG. 1





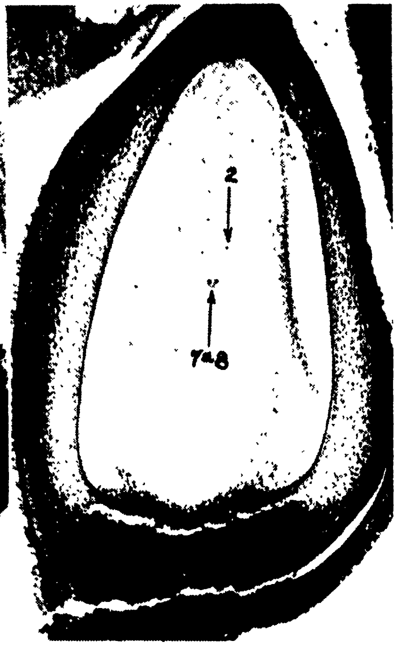

Pl.2.-5
Pl.2.-7
Pl.2-9
Pl.1-2



Pl.1.-4 Pl.2.-8

Pl.2.-6 Pl.2.-10

Pl. 3.-1



Pl. 3.-3

Pl. 3.-2

Pl. 3.-4

Pl. 4.-5

Pl. 4.-7

Pl. 4.-6

Pl. 4.-8

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 167-170, July, 1947.*

A NEW SPECIES OF LILIACEAE WITH SIX SOMATIC CHROMOSOMES

BY

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Read 3rd July, 1946.

In 1937 Darlington (1) mentions no more than nine species of flowering plants with a number of haploid chromosomes as low as three: *Crepis capillaris, Callitriche autumnalis, Zacintha verrucosa,* and six species of Crocus.

During our cytological studies we have discovered a further example in the family Liliaceae. The plant is very common in Lourenço Marques and was at first thought to be a species of Urginea. Later on herbarium specimens were submitted to Miss Leighton, the author of " A revision of the South African Species of Ornithogalum L.", who kindly determined our plant as *Ornithogalum virens* Lindl. Unfortunately Miss Leighton did not have the opportunity of examining living specimens of this plant nor could we discuss this case with her personally. The morphological distinctions between the two genera are rather inconspicuous and of a quantitative character. The " Flora of Tropical Africa " mentions the following distinctive characters for the two genera:—

Urginea		*Ornithogalum*
	Filaments of the stamens.	
Filiform or slightly flattened.		Often flattened.
	Capsule.	
Deeply tri-lobed.		Not deeply lobed.
	Seeds.	
Flat.		Not compressed.

In our plant the filaments of the stamens are *deeply* flattened, the capsule is tri-lobed, and the seeds are *strongly compressed. Ornithogalum virens* Lindl, according to the diagnosis given by Miss Leighton, has flattened seeds in spite of being an Ornithogalum. The bracts are attenuated, *exceeding the flowers* in length, but in our case the bracts are *much shorter* than the flowers.

As we are not taxonomists, we leave the identification of this plant to specialists. Nevertheless, from available literature we have the impression that the distinctions between the different genera of the tribe Scilleae are rather indefinite and

more or less artificial, species having been frequently changed from one genus to another by different authors. A caryo-systematic study of the whole tribe would therefore be highly desirable.

The basic chromosome numbers of the different genera of the Scilleae are, according to Darlington and Janaki (2), as follows:—

Bellevalia (Hyacinthus) ..	x = 4
Dipcadia	x = 4, 9
Pushkinia	x = 5
Urginea	x = 5
Ornithogalum	x = 5, 6, 7, 8, 9
Scilla	x = 6, 7, 8, 9, 10, 11
Chionodoxa	x = 9
Lachenalia	x = 7, 8, 11, 13
Hyacinthus	x = 8, 14
Galtonia	x = 8
Muscari	x = 9
Drimiopsis	x = 10
Eucomis	x = 15, 16
Camassia	x = 15

From Urginea only a few species have been studied from a caryological point of view: *U. maritima* (= *U. scilla*) and some of its varieties, *U. indica* and *U. polyphylla*. In the first species mentioned, besides diploid forms with 2n = 10, hexaploid and octoploid forms have been found with 30 and 40 somatic chromosomes. In addition to these forms, others with a supplement of one to four chromosme fragments have also been found.

Darlington and Janaki mention eleven studied species of Ornithogalum with the following somatic chromosome numbers: 10, 12, 14, 16, 18, 24, 27, 30, 32, 50, 54.

We are not familiar with any caryo-systematic investigation of all species of either of these two genera.

In any case, the finding of a new species with such a low number of chromosomes is of considerable interest for a better understanding of the phylogenetic relationships of the different species.

The material is excellent for teaching purposes as well as for chromosome investigations.

The three chromosomes are almost of the same length with apparently terminal constrictions. One of the three pairs of chromosomes bears trabants.

During meiosis pairing is regular, the sat-chromosomes being attached to the nucleolus, as is usally the case.

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EXPLANATION OF THE PLATE.

Fig. 1, 2, and 3: Somatic metaphases of root-tip cells, showing the six chromosomes. In Fig. 3 (1 and 2) the two sat-chromosomes can be seen. (× 1.040.)

Fig. 4: Diakinesis of the pollen mother-cells. In some of these cells the three pairs of chromosomes can be distinguished, one of them (1), the sat-chromosomes, being always attached to the nucleolus. (× 1.040.)

Fig. 5, 6, and 7: Meiosis of the first reduction division of the pollen mother-cells, showing the three pairs of homologous chromosomes. (× 1.040.)

Material fixed in Brunn modification of Nawa shin mixture (Sol. A: chrom. acid 2 gr., acetic acid 20 cc.; water 130 cc.; Sol. B: formol 37 cc. diluted to 150 cc.; aa, embedded, sectioned and stained 1 to 6 in iron heamatoxylin, 7 in gentian violet).

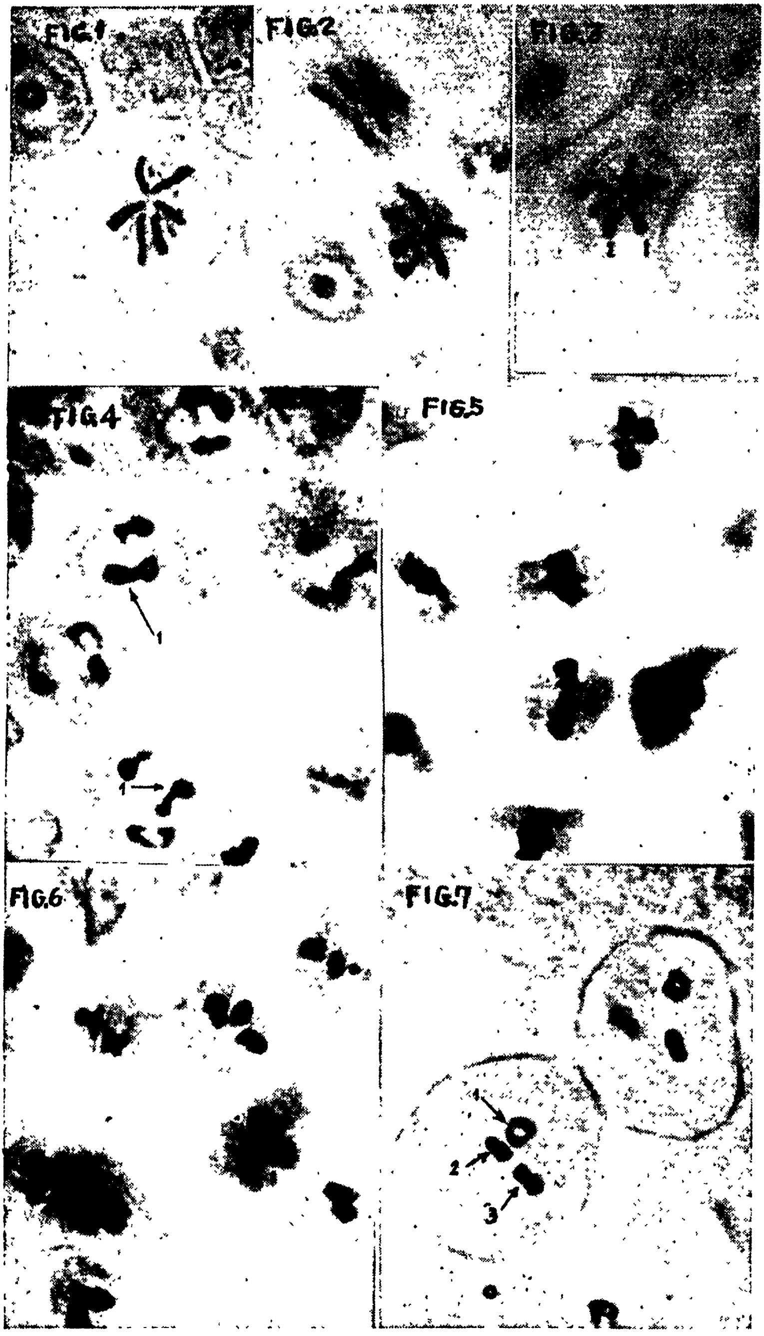
FIG.1
FIG.2
FIG.3
2
1
FIG.4
1
1
FIG.5
FIG.6
FIG.7
1
2
3

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII*, *pp.* 171-187, *July*, 1947.

DIE ONTWIKKELING VAN DIE SAADKNOP EN SAAD BY DIE MYOPORACEAE EN DIE SYSTEMATIESE POSISIE VAN OFTIA, ADANS,

DEUR

DR. M. P. DE VOS,
Universiteit van Stellenbosch.

Met 63 Figure.

Gelees 3 Julie 1946.

Oftia, Adans. met sy twee inheemse spesies *O. africana* Bocq. en *O. revoluta* Bocq., is 'n genus wat moeilikheid in die sistematiek veroorsaak. In die ouer literatuur, b.v. die van Endlicher, is die genus in die Verbenaceae geplaas. Bocquillon (1861) meen egter dat dit beter in die Scrophulariaceae tuishoort weëns die bou van die gynaecium. In die sisteme van Bentham en Hooker (1876) en van Engler en Prantl word dit onder die Myoporaceae geplaas, en Wettstein (1895 in E. en P.) wys daarop dat dit naverwant aan die Verbenaceae is. In 'n monografie oor die Myoporaceae meen Kränzlin (1929) egter dat die genus beter in die Verbenaceae tuishoort weëns die bloeiwyse wat soms bepaald is en die bou van die vrugbeginsel. Maar Junell (1934) wat die morfologie van die gynaecium by die Verbenaceae behandel, toon dat Oftia nie aan hierdie familie hoort nie, weens die stand van die saadknoppe.

Met die oog op die onsekerheid oor die systematiese posisie van die genus is hierdie werk onderneem, en omdat net een spesies van die Myoporaceae gedeeltelik embryologies ondersoek is (Billings 1901), is meer lede van hierdie familie ook ondersoek.

Metode.—Vrugbeginsels is in die Karpechenko-modifikasie van Navashin se vloeistof of in FAA fikseer. Mikrotoomsnitte is 10 tot 15 μ dik gesny en is in Heidenhain se ysteraluin-haematoxylin geverf, soms met oranje-G in naeltjieolie as kontraskleurstof. Delafield se haematoxylin is soms as kleurstof in ouer vrugbeginsels gebruik. Mikrogemiese toetse is uitgevoer om die geaardheid van die wande en die inhoud van verskillende selle te bepaal.

Materiaal van *Eremophila Duttoni, E. Mitchelli* en *E. longifolia* is deur die goedgunstige medewerking van Prof. E. Ashby van die Universiteit van Sydney en Dr. N. Beadle van die Grondbewaringsdiens van N.S.W. verkry. Prof. J. S. Wood van die Universiteit van Adelaide het materiaal van *E.* (*Pholidia*) *scoparia* verskaf. Die materiaal is hierheen gestuur in die FAA-fikseermiddel en het in goeie toestand aangekom. Materiaal van

Oftia africana en *Myoporum acuminatum* is ter plaatse gekry. *O. revoluta* is deur die medewerking van Mev. Levyns uit Namakwaland verkry.

ONDERSOEKING.

EREMOPHILA, R. BR. *Posisie van die saadknoppe.* Die tweehokkige vrugbeginsel is gevorm van twee vrugblare, die rande waarvan in die hokke ingroei tot byna teen die buitewand, en 'n massiewe placenta vorm wat die vrughok grotendeels vul. Hierdeur word die saadknoppe teruggedruk na die skeiwand en mond met hul mikropyle uit in die hoek wat die skeiwand met die placenta vorm (fig. 1).

Die saadknoppe is sessiel, anatroop en hangend met dorsale raphe. By *E. longifolia* is hulle byna hemitroop. By *E. scoparia* is daar een paar saadknoppe in elke hok, by *E. Duttoni* een tot twee pare (fig. 2), by *E. longifolia* twee paar en by *E. Mitchelli* drie tot vier paar, in rye bo mekaar aan elke kant van die placenta. By *E. longifolia* en *E. Duttoni* lê die saadknoppe direk bo mekaar, maar by *E. Mitchelli* brei die placenta uit tussen die saadknoppe in die ry en vorm 'n obturator oor die mikropyl (fig. 1-4).

Die ontwikkeling van die kiemsak voor bevrugting by E. longifolia F. Muell. Die saadknop ontstaan as 'n klein uitstulping op die placenta. Die archespoorsel is subepidermaal en bly in hierdie posisie aangesien g'n deksel afgesnoer word nie (fig. 5, 6). Dit funksioneer direk as makrospoormoedersel en 'n liniêre ry van vier makrospore ontstaan daaruit wat deur die nucellus van een laag selle omring is (fig. 7). 'n Enkele massiewe integument groei uit die basis van die nucellus, sluit dit in en laat 'n lang mikropyl ontstaan. In hierdie stadium word die binneste epidermis van die integument tot 'n tapetum of mantellaag gedifferensieer (fig. 7, 8), die selle waarvan plasmaryk is en meristematies bly solank die kiemsak groei. Hul binnewande wat aan die nucellus grens, is oortrek met 'n dun cuticula.

Gewoonlik funksioneer die chalazale makrospoor, en terwyl dit vergroot, word die ander makrospore geabsorbeer (fig. 8). Die ontwikkeling van die makrospoor tot kiemsak is die normale tipe (fig. 9, 10, 11) soos deur Schnarf (1929) en Maheshwari (1937) beskrywe. Die nucellus degenereer alreeds vroeg sodat die jong tweekernige kiemsak teenaan die tapetum lê met alleen oorblyfsels van die nucellus tussenin (fig. 9). Dit steek met 'n naakte punt verby die nucellus-oorblyfsels. Die jong vierkernige kiemsak is alreeds lank en stoot met sy punt verby die tapetum in die mikropyl op (fig. 10).

Die volwasse kiemsak (fig. 11) besit 'n eisel, twee synergidae, drie antipodale selle en twee polare kerne wat voor bevrugting versmelt. Waar die kiemsak bo nie deur die tapetum begrens

is nie, is dit breed. Die mikropilêre selle wat die punt van die kiemsak omring, bevat setmeel, en na bevrugting is setmeel ook in die kiemsak aangetref (fig. 5-11).

Die ontwikkeling van die kiemsak voor bevrugting by *E. Mitchelli* Benth. en *E.* (*Pholidia*) *scoparia* F. Muell. is net soos by die vorige spesies, behalwe dat by *E. scoparia* 'n makrospoor tweede vanaf die chalaza in een geval funksioneer, en by *E. Mitchelli* kan die tweede of derde makrospoor vanaf die chalaza soms funksioneer.

By *E. longifolia* en *E. scoparia* is al die saadknoppe van 'n vrugbeginsel in dieselfde stadium van ontwikkeling, maar soms is sommige saadknoppe by *E. Mitchelli* nog in die makrospoorstadium, terwyl ander van dieselfde vrugbeginsel gereed is vir bevrugting. *E. Mitchelli* toon soms die volgende abnormale toestande: Twee uit die vier makrospore ontwikkel tot kiemsak. Twee archespoorselle ontwikkel in 'n saadknop, sodat daar later twee kiemsakke in aparte tapeta lê. Abnormale kiemsakke is gevind, b.v., 'n groot kiemsak met een kern in elke punt, en 'n kiemsak met 'n ei-apparaat, twee antipodes en 'n string van vier kerne in die middel.

Die ontwikkeling van die endosperm en kiem by *E. Duttoni* F. Muell. Die volwasse kiemsak is normaal en het dieselfde bou as in *E. longifolia* (fig. 12). Die endosperm ontwikkel deur selvorming vanaf die begin. Die primêre endospermkern deel en die dogterkerne word deur 'n horisontale wand van mekaar geskei (fig. 13). Beide selle deel deur twee lengtewande reghoekig op mekaar, sodat daar nou agt selle aanwesig is (fig. 14, waar vier van die selle getoon word). Die lengtedeling van die apikale sel geskied baie stadiger as in die basale sel, omdat eersgenoemde veel groter en wyer is en groot vakuoles besit. Die lengtewande word deur 'n klein phragmoplast en selplaat neergelê wat van onder na bo beweeg (fig. 14). Die vier apikale selle wat so ontstaan, is wyd na bo waar hulle nie deur die tapetum begrens word nie.

Hierdie vier selle deel gelyktydig met horisontale wande, sodat die kiemsak drie lae met vier selle in elke laag besit (fig. 16, waar twee selle van elke laag getoon word). Die vier boonste selle bly breed en arm aan protoplasma, en die middelste en basale selle is lank, smal en plasmaryk. Die degenererende antipodes is tot op hierdie stadium waarneembaar.

Die onderste punte van die vier basale selle verbreed effens waar hulle verby die tapetum steek, en vorm 'n klein chalazale haustorium (fig. 17, 20), wat vroeg sy verbinding met die endosperm verloor. Die vier boonste selle vergroot nie. Of hierdie boonste en onderste selle verdere delings ondergaan om te help met die vorming van die endosperm, kon nie waargeneem word nie.

Die vier middelste selle ondergaan 'n groot aantal delings deur horisontale wande, waardeur die kiemsak omtrent viermaal langer word maar vereers smal bly (fig. 17). Hierdeur verleng die saadknop ook. Die tapetum is in sy onderste helfde meristematies en hou tred met die verlenging van die kiemsak. Maar die middellae van die integument skeur later sodat daar groot ruimtes ontstaan. Die werklike endospermweefsel ontstaan alleen in die middel van die lang kiemsak. Hier word dit vinnig breër deurdat die endospermselle met lengtewande en onreëlmatig deel (fig. 18). Maar die mikropilêre en chalazale punte van die kiemsak bly smal en neem nie deel aan die vorming van die endosperm nie. Die tapetum word inmekaar gedruk deur die ontwikkeling van die endosperm in die middel. Fig. 12-24.

Die mikropilêre haustorium bestaan uit die vier boonste selle en die plasmaryke smal punt van die endospermweefsel wat daaraan grens (fig. 19). Dit is dus veelsellig.

Die viersellige chalazale haustorium verloor vroeg sy verbinding met die endosperm—'n spasie ontstaan (fig. 20). Bo die chalazale haustorium bly die punt van die kiemsak smal en is gevul met plasmaryke endospermselle (fig. 20), wat later deur die vinnige ontwikkeling van die middelste deel van die endospermweefsel inmekaar gedruk (fig. 21) en geabsorbeer word.

Die zygoot wat rus totdat die endosperm begin verbreed, ontwikkel tot 'n lang buisvormige voorkiem met die kern aan die punt. Dit groei tussen die endospermselle in tot dit die verbreedte gedeelte bereik (fig. 19). Die kiem ontwikkel volgens die Cruciferae-tipe (Schnarf 1929) en die Onagraceae-tipe (Johansen, 1945). Die punt van die voorkiem deel deur 'n dwarswand wat die apikale van die basale kern skei (fig. 22). Die apikale sel vorm die kiem, eers deur twee delings d.m.v. lengtewande reghoekig op mekaar te ondergaan (fig. 23). Hierdie vier selle deel gelyktydig deur horisontale wande om die oktantstadium te vorm. Deur perikline wande word 'n sestien-sellige kiem gevorm, en die perifere selle deel deur antikline wande (fig. 24) om 'n 24-sellige kiem te vorm. Intussen vorm die basale kern deur dwarsdeling 'n veelsellige suspensor, met 'n driehoekige sel, die hipophyse, styf teen die kiem. Dit word tweesellig en neem deel aan die ontwikkeling van die kiem. Verdere stadiums is nie waargeneem nie.

Ontwikkeling van die endosperm en kiem by *E. scoparia* en *E. longifolia*. Geïsoleerde stadiums is aangetref wat toon dat die ontwikkeling hier net soos by *E. Duttoni* plaasvind.

By *E. longifolia* is die eerste deling van die primêre endospermkern deur 'n dwarswand.

By *E. scoparia* toon die jong endosperm ook eers 'n uitgesproke verlenging. Later verbreed die middelste gedeelte om die werklike endospermweefsel te vorm (fig. 25), terwyl haustoria aan die twee punte ontwikkel. Die protoplasma van die twee

haustoria word geabsorbeer, maar die lang smal holte waar die mikropilêre haustorium geleë was, en die korter breë holte van die chalazale haustorium is nog sigbaar (fig. 25). Beide holtes is afgegrens van die endospermweefsel deur membraanlae gevorm van platgedrukte selle. Die integument word langs die kante platgedruk, maar langs die mikropilêre haustorium is dit nog breed en toon dit groot spasies waar die integumentselle geskeur het (fig. 25-29).

Die byna ryp saad by *E. scoparia* en *E. longifolia*. Deur die verlenging van die kiem word die holtes van die twee haustoria inmekaar gedruk, asook die binnelae van die integument (fig. 26). Die kiem toon 'n goedontwikkelde kiemworteltjie met pleroom, peribleem en dermatogeen, twee groot saadlobbe ryk aan aleurone, en 'n klein meristematiese knoppie waar die pluimpie later ontwikkel. Die endosperm is blywend en bevat groot hoeveelhede aleurone en waarskynlik ook olie (die alkohol in die fikseermiddel sou die olie oplos), maar geen setmeel. Dit word van die kiem deur 'n lagie leë endospermselle afgegrens. Sommige van die endospermselle waarteen die wortelpunt stoot, word platgedruk (fig. 27).

Die saadhuid bestaan uit (1) die epidermis van die integument, waarvan die binnewande verdik en verhout en gestippeld is, en die buitewande later verdwyn, (2) 'n membraan bestaande uit die platgedrukte tapetum en middellae van die integument, en (3) 'n gekutiniseerde laag teen die endosperm (fig. 28), wat waarskynlik die cuticula van die tapetum is. By die boonste punt is sommige middellae van die integument nie platgedruk nie, maar toon ring- en leervormige verdikkings van lignin aan (fig. 27). Die membraan wat die ou haustoria van die endosperm afskei, is geel van kleur en baie dik, en is verkurk of gekutiniseerd (fig. 27, 29). Dit sluit aan by die gekutiniseerde laag van die saadhuid.

MYOPORUM, BANKS EN SOLAND.

M. acuminatum R. Br. Die vrugbeginsel het drie of soms vier hokke met een hangende anatrope saadknop met 'n lang funiculus en dorsale raphe in elke hok. Dit ontwikkel as 'n uitstulping uit die okselstandige placenta (fig. 3, 4).

Die ontwikkeling van die saadknop voor bevrugting is net soos by *Eremophila longifolia*. Die archespoorsel is subepidermaal en g'n deksel word gevorm nie (fig. 30). Een integument ontstaan uit die basis van die nucellus en die binneste epidermis daarvan ontwikkel tot 'n' tipiese tapetum. Uit die archespoorsel ontwikkel 'n ry van vier makrospore waarvan die chalazale een vergroot (fig. 32) en die kiemsak vorm, terwyl die ander makrospore asook die nucellus degenereer. Die ontwikkeling van die kiemsak is volgens die normale tipe, en 'n normale

agtkernige kiemsak ontstaan met dieselfde bou as by *E. longifolia* (fig. 34).

Die ontwikkeling van die endosperm en kiem. Die vroeë ontwikkeling van die endosperm geskied net soos by *E. Duttoni.* die lengte as van die kiemsak, en snoer die kiemsak dus in. en daarna deel beide selle deur twee lengtewande reghoekig op mekaar. Die wande in die boonste sel word ook deur 'n klein bewegende phragmoplast en selplaat neergelê (fig. 36). Die vier boonste selle deel dan gelyktydig deur dwarswande (fig. 37).

Die vier onderste selle vorm 'n klein chalazale haustorium (fig. 38, 39). Dit is onbekend of die boonste en onderste selle verder deel, maar die middelste selle deel deur dwarswande, en die kiemsak neem dus in lengte toe (fig. 38). Die tapetum is meristematies in sy middelstreek en verleng om tred te hou met die verlengende endosperm. In sommige saadknoppe verleng die tapetumselle in die middel van die saadknop reghoekig tot die lengte as van die kiemsak, en snoer die kiemsak dus in. Sulke saadknoppe degenereer gewoonlik.

In saadknoppe wat verder ontwikkel verbreed die endospermweefsel net in die middel en druk dit die tapetum en binnelae van die integument plat. Die punte bly smal. Die mikropilêre punt vorm 'n veelsellige haustorium. Hierdie smal punte word later deur die ontwikkelende endosperm geabsorbeer, en wanneer hulle leeg is word hulle van die endosperm afgesny deur 'n membraanlaag wat in die ryp saad verkurk.

Net soos by *E. Duttoni* word 'n lang buisvormige voorkiem gevorm wat die kern tot in die breë deel van die endosperm vervoer. Na die eerste kerndeling sny 'n dwarswand die apikale sel af van die basale sel, wat 'n meersellige suspensor vorm. Dit bly lank behoue en is te sien onder aan die worteltjie selfs na die differensiasie van die kiem. Die ontwikkeling van die apikale sel tot kiem is nie waargeneem nie.

Die bou van die volwasse saad is identies met die van *E. longifolia* en *E. scoparia.*

OFTIA, ADANS.

O. africana Bocq.: Die tweehokkige vrugbeginsel besit vier hemitrope saadknoppe in elke hok. Die placenta wat uit die vrugblaarrande ontwikkel, is hoog op die skeiwand geleë, en die saadknoppe lê in pare bomekaar met kort breë funiculi. Hulle is op so 'n manier gedraai dat 'n lengtesnit deur die as nie deur die raphe en kiemsak kan gaan nie (fig. 41). Hulle is hangend met kort raphes wat nog ventraal nog dorsaal is, maar 'n tussenposisie beklee (fig. 49—53). Die gebuigde mikropyl is skuins na bo gekeer, na die buitenkant by die onderste saadknoppe en na die binnekant by die boonste saadknoppe.

Die ontwikkeling voor bevrugting. Die archespoorsel lê subepidermaal en g'n deksel word gevorm nie (fig. 42). Dit verleng en funksioneer as makrospoormoedersel (fig. 43). 'n Ry van vier makrospore ontstaan daaruit, en die chalazale een ontwikkel tot kiemsak ten koste van die ander wat degenereer (fig. 44). Die kiemsak ontwikkel normaal, en die kern deel driemaal (fig. 45—47). Die volwasse kiemsak besit twee baie lang synergidae, 'n eisel, twee polare kerne wat tot sekondêre kiemsakkern versmelt, en drie antipodale selle wat vroeg verdwyn, sodat 'n kiemsak gereed vir bevrugting hul aanwesigheid nie meer toon nie (fig. 47, 48).

Die nucellus bo en aan die kant van die jong kiemsak word vroeg geabsorbeer, maar aan die basis van die kiemsak bly 'n groep nucellusselle behoue tot die endosperm begin ontwikkel (fig. 45—48). Hulle is effens verleng en arm aan protoplasma. Die enkele breë integument ontwikkel uit die basis van die nucellus voordat die makrospoormoedersel deel (fig. 45), en laat 'n lang gebuigde mikropyl ontstaan. Die binneste epidermisselle word tot 'n tipiese tapetum gedifferensieer, wat langs die blywende nucellus tot by die chalaza strek (fig. 45—48). Dit is met 'n cuticula bedek. Die boonste helfde van die kiemsak is nie met die tapetum en cuticula begrens nie, en lê in aanraking met gewone integumentselle wat alreeds vroeg ryk aan setmeel is. Onder die blywende nucellus is 'n groep sterk ligbrekende selle aanwesig met dik wande wat 'n houtreaksie toon (fig. 48), en 'n hypostase (van Tieghem) vorm. Die lei-elemente van die raphe eindig teenaan hulle.

Na die bevrugting verdwyn die synergidae, en die zygoot rus.

Die ontwikkeling van die endosperm en kiem. Die endosperm toon 'n sellulêre ontwikkeling vanaf die begin. Na die eerste deling van die primêre endospermkern ontstaan 'n dwarswand. Na 'n paar verdere delings wat nie waargeneem is nie, bevat die kiemsak vier endospermselle bo, vier in die middel en twee onder (fig. 54). Laasgenoemde twee selle wat ryk aan setmeel is, deel deur 'n lengtewand om ook vier selle te vorm (fig. 57). Die rustende zygoot lê tussen die punte van die boonste selle.

Die vier boonste endospermselle wat waarskynlik nie verder deel nie, vergroot en vorm 'n enorme mikropilêre haustorium van 320 x 250 μ, wat uitstulpings tussen die integumentselle stuur om voedsel te absorbeer. Die kerne toon 'n hipertrofie. Die haustorium is nie deur die tapetum met sy cuticula begrens nie, en is in verbinding met die endosperm deur 'n baie nou nekkie (fig. 56).

Die chalazale haustorium word deur die vier basale endospermselle gevorm wat waarskynlik vroeg opgehou het om verder te deel. Dit los die basale nucellus op wat tot nou aanwesig

was, en groei tot teenaan die hipostase, sodat sy punt effens verby die tapetum steek (fig. 58). Dit word vroeg deur die ontwikkelende endosperm geabsorbeer, wat dan effens in die haustoriële ruimte instulp (fig. 63).

Die vier middelste selle van die jong endosperm deel deur dwarswande totdat dit omtrent 12 selle lank is, en daarna verbreed dit deur onreëlmatige delings (fig. 55).

Wanneer die endospermweefsel verbreed, ontwikkel die zygoot tot 'n lang silindriese voorkiem wat in die endospermweefsel ingestoot word met die kern aan die punt (fig. 55). Met die eerste deling ontstaan 'n apikale en 'n basale sel. Daarna is 'n oktante en 'n sestien-sellige stadium waargeneem wat waarskynlik net soos by *Eremophila Duttoni* ontstaan (fig. 59, 60). Die basale sel deel 'n paar maal d.m.v. dwarswande om 'n kort suspensor te vorm, die boonste sel (hipophyse) waarvan aan die vorming van die kiem deelneem.

Die ryp saad. Die kiem is net soos by *E. longifolia* en *E. scoparia.* Die blywende endosperm bevat aleurone, olie en verdikte sellulose wande. Die chalazale haustorium het verdwyn, maar die hipostase is nog te sien. Die mikropilêre haustorium is platgedruk en bestaan uit breë opmekaargedrukte sellulose balke. Die tapetum is blywend en vorm met sy cuticula die binneste laag van die saadhuid. Die binnewonde van die tapetumselle toon breë onreëlmatige verdikkings wat bruin van kleur is en 'n houtreaksie lewer met phloroglucin (fig. 62). Sommige tapetumselle vergroot en stoot diep in die endospermweefsel in (fig. 55, 61). Die middellae van die integument word inmekaargedruk, en die epidermis bly dun en skilwer af.

Oftia revoluta. Die bou van die vrugbeginsel, die posisie en getal van saadknoppe, en die ontwikkeling en bou van die saadknoppe tot by die bevrugting is identies met die van *O. africana.* Stadiums na die bevrugting is nie waargeneem nie.

Bespreking.

Wat die sistematiese posisie van die genus Oftia betref, moet ons met Junell (1934) saamstem dat dit nie in die Verbenaceae tuishoort nie. Die mikropyl en kiemworteltjie by die Verbenaceae is onderstandig, en by Oftia is dit bostandig.

Verder bestaan daar twee moontlikhede: die genus kan óf in die Selaginaceae óf in die Myoporaceae geplaas word. Van eersgenoemde verskil dit in die bou van die vrug ('n steenvrug by Oftia en twee of soms een neutjie by die Selaginaceae), die bloeiwyse (enkele okselstandige blomme en baie selde 'n bepaalde bloeiwyse met drie blomme in 'n blaaroksel by Oftia, en 'n aar of soms 'n tros by die Selaginaceae), en in die getal saadknoppe (4 in elke hok in pare bo mekaar gerangskik by Oftia, en een

in elke hok by die Selaginaceae). In laasgenoemde opsig stem die genus ooreen met Eremophila.

·Oftia verskil van die Myoporaceae in die bou van die vrugbeginsel, die bloeiwyse (Kränzlin, 1929) en in die afwesigheid van olieholtes. Olieholtes kom by die meeste geslagte van die Myoporaceae voor, maar nie in Oftia nie. Volgens Wettstein (1895) besit die Myoporaceae enkele of groepies blomme wat bepaald lyk in die blaaroksels. Kränzlin se hele werk was nie ter insage nie, en dit is dus onseker waarop hy sy bewering bou. Wat die bou van die vrugbeginsel betref, is die enigste werklike verskil dat die tweehokkige vrugbeginsel vroeg in die ontwikkeling deur valse wande of deur die placenta in meer hokke verdeel word (Myoporum) of byna verdeel word (Eremophila), terwyl dit nie in Oftia geskied nie.

Verder stem die vrugbeginsel van Oftia met beide die Myoporaceae en die Selaginaceae ooreen in die besit van hangende anatrope (of hemitrope) saadknoppe met bostandige mikropyle en worteltjies. By Oftia is die raphe tussenstandig (Junell fouteer deur die saadknoppe hier epitroop te noem), by die Selaginaceae dorsaal, ventraal of tussenstandig (de Vos, 1945) en by die Myoporaceae dorsaal, maar by *Myoporum humile* tussenstandig (Wettstein, fig. 144 R, S). In die genus Stilbe vind Junell ook dorsale en ventrale raphes, en dit skyn asof die posisie van die raphe in hierdie families geen sistematiese waarde het nie.

Die ontwikkeling van die saadknop en saad by die ondersoekte soorte is in hoofsaak eenders en is tipies vir die Sympetalae. Die ontwikkeling toon verder dat Myoporum en Eremophila baie naverwant is (dit is eenders in hierdie geslagte), en dat Oftia verder staan. Die volgende verskille kom in die ontwikkeling tussen Oftia, die Selaginaceae (de Vos) en die ondersoekte Myoporaceae voor:—

'n Dikwandige hipostase kom in die chalazale wyk by Oftia voor en is afwesig by die ander. Sover vandag bekend, skyn dit asof so 'n weefsel g'n sistematiese waarde het nie.

By Oftia is 'n basale deel van die nucellus blywend tot die chalazale haustorium dit later absorbeer, en by die ander verdwyn dit vroeg. Die sistematiese waarde van hierdie kenmerk is waarskynlik min, want in die Scrophulariaceae kom beide tipes voor: Pedicularis-soorte toon persisterende basale nucellus, maar by meeste geslagte verdwyn dit vroeg (Schmid, 1906).

By Myoporum en Eremophila word die lengtewande in die boonste endospermsel deur 'n klein bewegende phragmoplast neergelê, iets wat in verband staan met die grootte van daardie sel en waarskynlik sonder sistematiese waarde is. By Oftia en die Selaginaceae ontstaan die lengtewande normaal.

By Oftia ontwikkel viersellige terminale haustoria uit die endosperm, die chalazale een klein en die mikropilêre een groot

en gehipertrofeerd. By Eremophila en Myoporum kom viersellige terminale endospermhaustoria ook voor, maar later word die mikropilêre haustorium veelsellig (fig. 19). Billings (1901) gee vir *M. serratum* 'n soortgelyke haustorium aan. Aan die chalazale punt word baie endospermselle geabsorbeer in die ontwikkeling en hulle neem nie deel aan die vorming van die blywende endospermweefsel nie. By die Selaginaceae kom 'n klein tweesellige chalazale en 'n viersellige mikropilêre haustorium voor. Die haustoria van Oftia stem dus meer ooreen met die van die Selaginaceae. Maar in die Labiatae kom veelsellige en minsellige mikropilêre haustoria voor (Schnarf, 1929; 380, Junell), en selfs hierdie kenmerk het dus min waarde.

By Oftia is die tapetum blywend en vorm die binnelaag van die saadhuid, terwyl dit by die ander vroeg verdwyn. Of hierdie kenmerk enige sistematiese waarde het, is twyfelagtig, want in die Scrophulariaceae kom beide tipes voor (Netolitsky, 1926, Schmid).

Uit die voorgaande blyk dat die verskille in die ontwikkeling van die saadknop en saad sodanig is dat ons hulle met ons teenwoordige kennis van die embryologie nie sonder voorbehoud kan gebruik om die sistematiese posisie van Oftia te bepaal nie. By nadere ondersoek is die bou van die vrugbeginsel by Oftia en die ander Myoporaceae nie so erg verskillend nie, en vorm hulle 'n ontwikkelingsreeks met Oftia as primitief in hierdie opsig, waar die vrughokke nie deur die placenta ingeneem word nie.

Die genus staan in werklikheid halfpad tussen die Selaginaceae en die Myoporaceae, en kan myns insiens in laasgenoemde familie bly. Dit is wel nie baie naverwant aan die Australiese soorte nie, maar so iets is te verwagte omdat dit in 'n ander wêrelddeel voorkom en baie vroeg van die ander geslagte van die Myoporaceae moes afgespruit het.

SUMMARY.

1. The development of the ovule and seed in species of Oftia, Myoporum and Eremophila is almost similar and conforms to that found in other genera of the Sympetalae.

2. A single archespore cell arises sub-epidermally and gives rise to a row of four megaspores, of which the lowest develops into a normal eight-nucleate embryo-sac. The nucellus soon disappears except in Oftia, where it persists at the base of the embryo-sac until after fertilization.

3. The endosperm is formed by cell division and endospermal haustoria develop. The four-celled chalazal haustorium is small. The micropylar haustorium consists of four hypertrophied cells in Oftia and of a large number of cells in Myoporum and Eremophila.

4. The fertilized egg-cell forms a long tubular pro-embryo, and in *E. Duttoni* the development of the embryo conforms to the Cruciferae type.

5. The seed is endospermous. The testa consists of collapsed integumentary cells and the lignified tapetum in Oftia, or the lignified inner walls of the outer epidermis of the integument in Eremophlia and Myoporum.

6. The systematic position of Oftia is discussed. The conclusion reached is that the genus stands midway between the Myoporaceae and the Selaginaceae, but that there is not enough reason to exclude it from the Myoporaceae.

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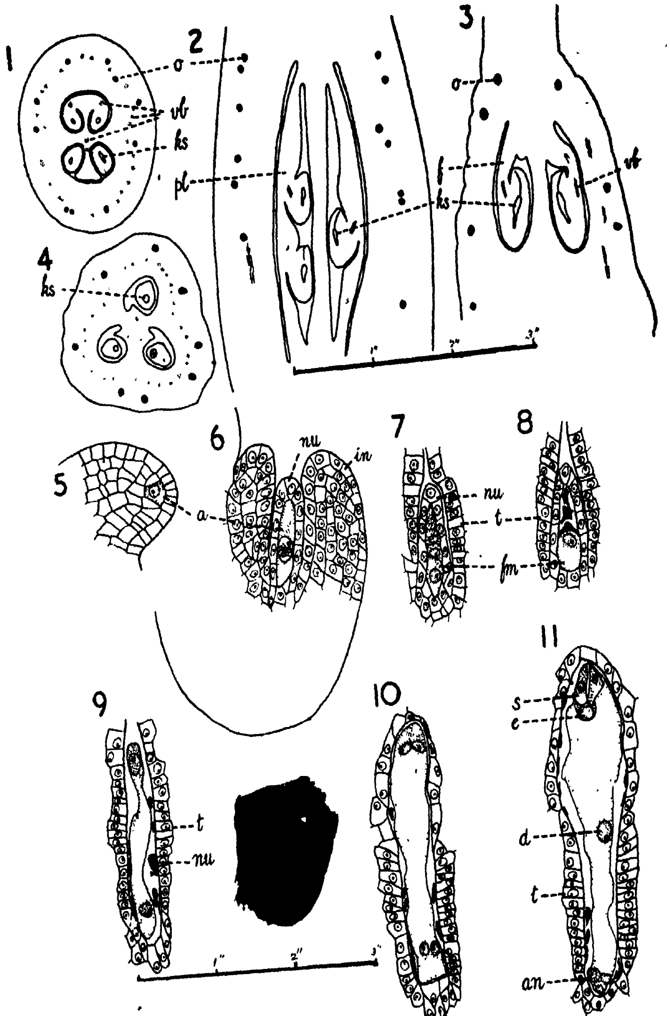
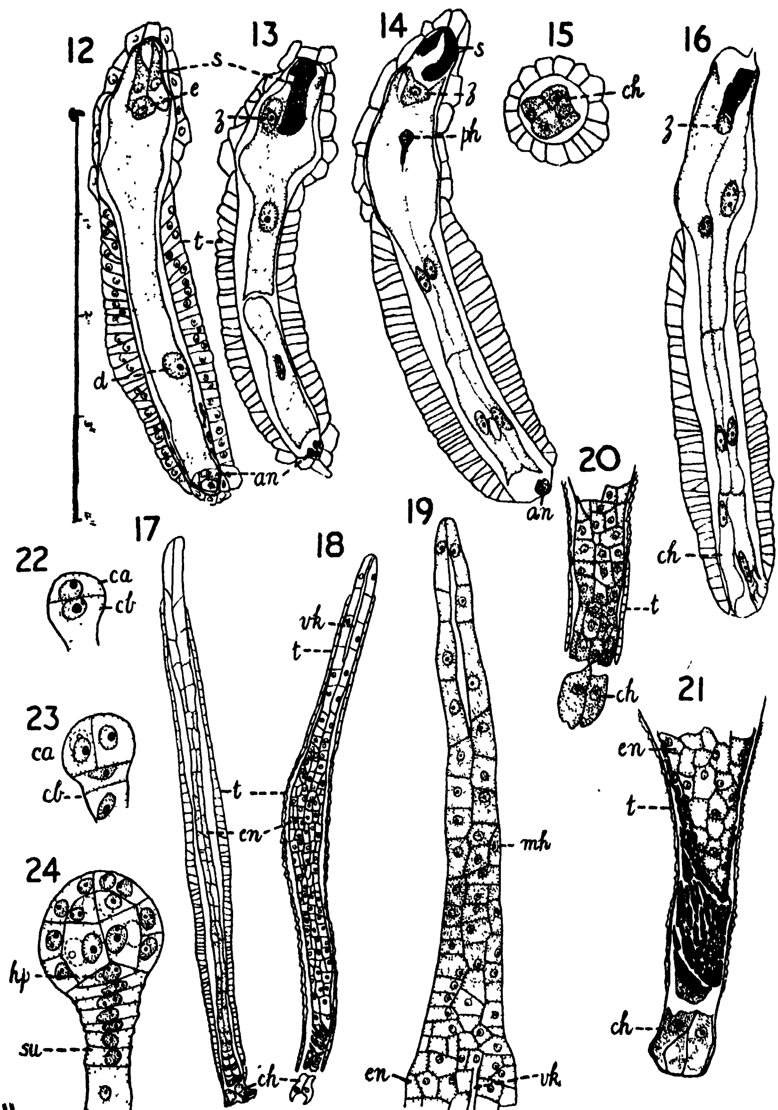
VERKLARING VAN DIE VERKORTINGS BY DIE FIGURE GEBRUIK.

a, makrospoormoedersel; an, antipodale selle; ca, apikale sel; cb, basale sel; ch, chalazale haustorium; cut, gekutiniseerde of verkurkte lae; d, sekondêre kiemsakkern; e, eisel; en, endosperm; ep, epidermis van integument; f, funiculus; fm, funksionerende makrospoor; hp, hipophyse; hy, hipostase; in, integument; in sp, integumentselle met spiraalvormige verdikkings; k, kiem; ks, kiemsak; m, mikropyl; mh, mikropilêre haustorium; nu, nucellus; o, olieholtes; pi, platgedrukte integumentselle; pl, placenta; r, raphe; s, synergidae; set, setmeel; si, geskeurde integumentselle; su, suspensor; t, tapetum; vb, vaatbundel; vk, voorkiem; z, bevrugte eisel.



Fige. 1, 2, *Eremophila Duttoni*: 1, dwarssnit deur vrugbeginsel, x 25; 2, lengtesnit deur vrugbeginsel, x 30. Fige. 3, 4, *Myoporum* acuminatum: 3, lengtesnit deur vrugbeginsel, x 40; 4, dwarssnit deur vrugbeginsel, x 30.

Fige. 5-11, *Eremophila longifolia*, x 400: 5, subepidermale makrospoormoedersel; 6, ontstaan van integument; 7, ry van vier makrospore; 8, funksionerende makrospoor; 9, jong kiemsak met twee kerne; 10, jong kiemsak met vier kerne; 11, volwasse kiemsak.



Figs. 12-24, *Eremophila Duttoni*: 12, volwasse kiemsak, x 400; 13, 14, 16, vroeë endospermvorming, x 400; 15, chalazale haustorium in dwarssnit, x 400; 17, verlenging van endospermweefsel, x 100; 18, endospermweefsel verbreed in die middel, x 80; 19, veelsellige mikropilêre haustorium, x 160; 20, chalazale haustorium, x 160; 21, ouer chalazale haustorium, x 160; 22, dwarsdeling van voorkiem, x 800; 23, kwadrantstadium van kiem, x 800; 24, koeëlvormige kiem met meersellige suspensor, x 800.

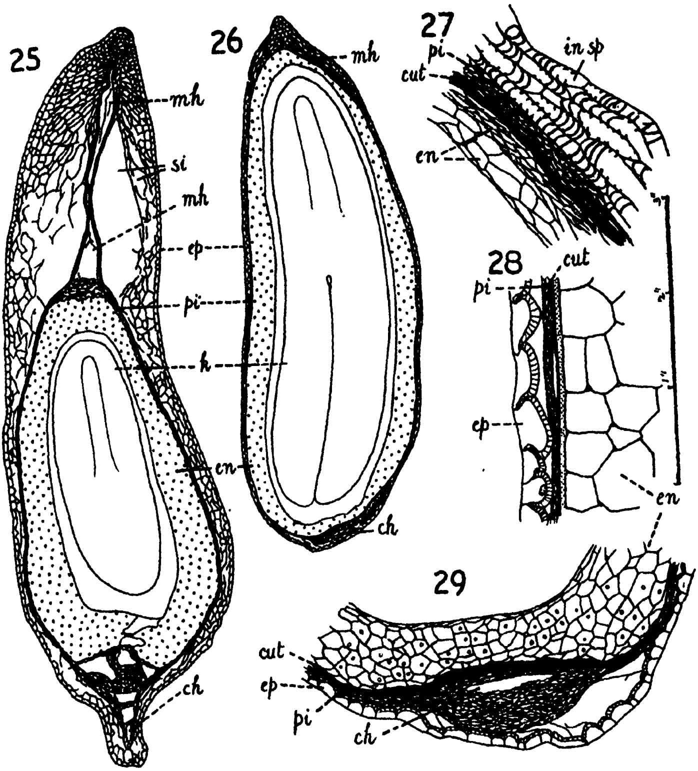
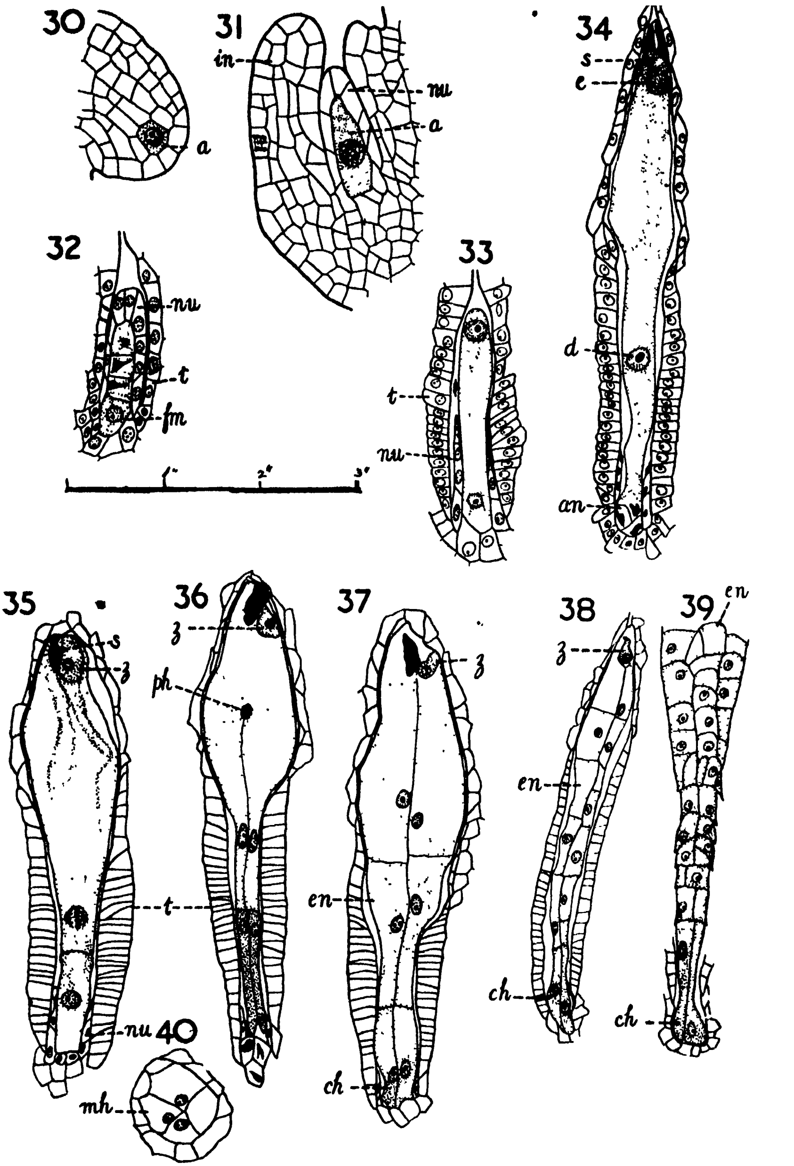
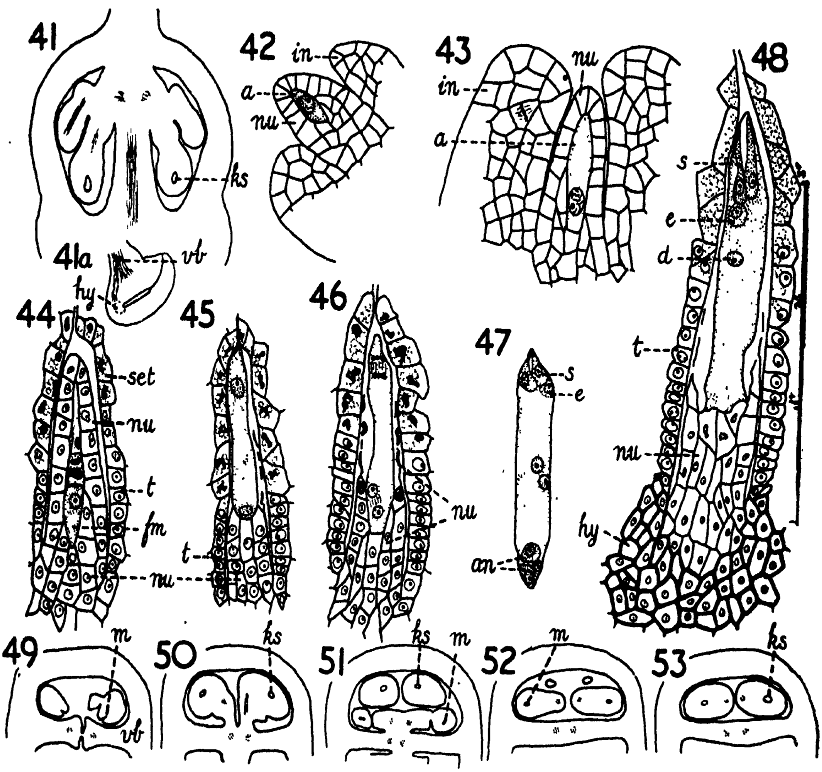


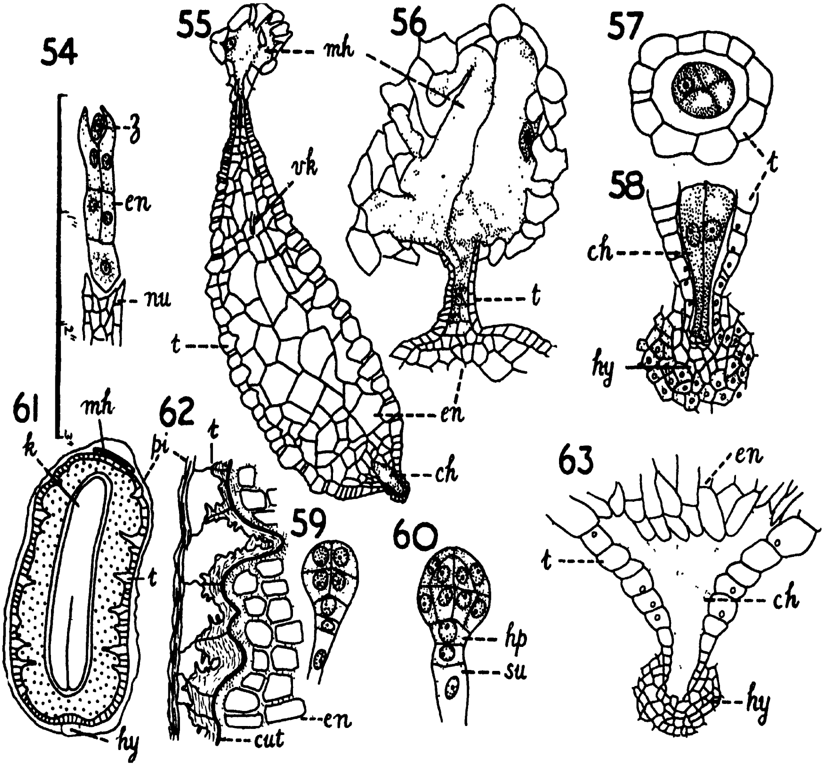
Fig. 25, *Eremophila scoparia*: lengtesnit deur jong saad, x 80; fige. 26-29, *E. longifolia*: 26, lengtesnit deur amper ryp saad, x 50; 27, snit deur saadhuid by mikropilêre punt, x 400; 28, snit deur saadhuid, x 400; 29, snit deur ou chalazale haustorium, x 200.



Fige. 30-40, *Myoporum acuminatum*: 30, subepidermale spoormoedersel, x 400; 31, ontwikkeling van integument, x 400; 32, ry van vier makrospore waarvan een funksioneer, x 400; 33, jong kiemsak met twee kerne, x 400; 34, volwasse kiemsak, x 300; 35, 36, 37, vroeë endospermvorming, x 300; 38, jong endosperm met chalazale haustorium en rustende zygoot, x 200; 39, chalazale haustorium, x 200; 40, dwarssnit deur mikropilêre punt van endosperm, x 300.



Figs. 41-53, *Oftia africana*: 41, lengtesnit deur vrugbeginsel, x 50; 41a, lengtesnit deur saadkop, μ ; 42, subepidermale spoormoedersel, x 600; 43, ontwikkeling van integument, x 600; 44, funksionerende makrospoor, x 600; 45, jong kiemsak met twee kerne, x 600; 46, jong kiemsak met vier kerne, x 600; 47, jong volwasse kiemsak, x 600; 48, volwasse kiemsak, x 600; 49-53, dwarssnitte deur die vrugbeginsel, 100 μ uitmekaar: 49, 50, 51, boonste saadknoppe; 51, 52, 53, onderste saadknoppe.



Fige. 54-63, *Oftia africana*: 54, jong endosperm, x 600; 55, endosperm met haustoria en voorkiem, x 100; 56, mikropilêre haustorium, x 200; 57, dwarssnit deur chalazale haustorium, x 400; 58, lengtesnit deur chalazale haustorium, x 400; 59, kiem in oktante stadium, x 600; 60, kiem in sestienselllige stadium, x 600; 61, lengtesnit deur ryp saad, x 30; 62, blywende tapetum in ryp saad, x 200; 63, lengtesnit deur ou chalazale haustorium, x 300.

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THE COMPRESSIBILITY OF WOOL AND ITS ROLE IN SOUTH AFRICAN MERINO WOOL PRODUCTION

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Read 3rd July, 1946.

The dimensional and physical attributes of the wool fibre play a decisive rôle in subsequent processing. It follows that these attributes are of fundamental importance to both producer and manufacturer, although the points of view of the two differ in some respects. Thus, the manufacturer selects his wool in accordance with his manufacturing requirements, while the producer, in addition to having to supply the needs of the manufacturer, has to consider economic and biological factors.

Unfortunately the link between producer and manufacturer is wholly unsatisfactory, probably owing to the common practice of estimating fleece characteristics subjectively, with the consequent inability of both producer and manufacturer to express the properties of the raw material in precise terms. Research has shown the errors inherent in human estimation, one of the aims of which should be to express the properties of wool in arithmetical terms so as to define the requirements of the manufacturer and provide the link between him and the producer.

Of the properties of wool, the dimensional attributes of the fibre and its behaviour under longitudinal stress have received most attention. On the other hand, the elastic behaviour of wool in bulk has been surprisingly neglected in view of the extent to which both producer and manufacturer rely on tactual examination in wool judgment, and the stress generally laid on various subjectively estimated characteristics known as " quality ", " handle ", " substance ", " harshness " and others which may be expected to involve the compressibility of wool.

In the present paper it is intended to present the results of studies now in progress on the compressibility of wool, and to indicate its rôle in the subjective estimation of wool characteristics and in breeding practice.

I. The Compressibility of Wool.

The shape of the pressure-volume curve for wool has been described by previous workers. It will suffice here to mention that the curve shifts with each successive cycle of compression and release, but finally attains a steady position. In addition, a considerable hysteresis occurs between the compression and release operations.

The arithmetical expression of the compressional characteristics of a wool sample has in the past been confined to measurement of the work done during compression and release, the doubtful method being employed of evaluating the work done between the same pressure limits for all samples. An exception occurs in the work of M. and J. Eggert, who fitted an equation to the compression curve. Their equation is, however, unsuitable for comparing different samples, and being empirical gives no indication of a relationship between compressibility and the characteristics of the fibres.

The compression of a mass of fibres involves several processes, but the problem is considerably simplified when reduced to that of simple bending of the fibres. If twisting, slippage and extension of the fibres are ignored, and the mass is regarded as a system of bending units, which are the elements of fibre between adjacent contacts with other fibres, a relationship between pressure and volume may be derived:—

$$P = \frac{K\,Y\,m^3}{\rho^3}\left(\frac{1}{v^3} - \frac{1}{v_0^3}\right).$$

where P is the pressure, Y is Young's modulus of flexural elasticity of the fibres, m is the mass, ρ the specific gravity and v is the volume. K is a numerical factor which may be determined empirically. This equation agrees with observations on the final constant cycle of compression of wool samples, except at the lowest degrees of compression where the density of packing of the material is not uniform. It is to be noted that the equation gives the resistance to compression as proportional to Young's modulus of flexural elasticity, but independent of fibre length and fibre diameter.

The constant K includes the variation in fibre characteristics, and consequently may be expected to vary slightly from sample to sample. Provided the variation is not too large, however, compressibility measurements may constitute a convenient method of comparing the flexural elastic properties of the fibres composing different wool samples, and of determining the effect of chemical and mechanical treatments on these properties.

In this connection it may be remarked that the value of Young's modulus of elasticity obtained by the extension of the fibre is not the same as that obtained by flexure. The determination of Young's modulus for wool fibres by flexure has never been attempted, being attended by considerable difficulty, but investigations now in progress aim at determining this quantity and thus evaluating the constant K. Should a reasonably constant value for K be obtained, the next step should be to determine the influence of fibre flexibility on spinning performance.

II. Compressibility in relation to other Factors.

In order to indicate the rôle of compressibility in practical wool production it is necessary to consider briefly the relationships between compressibility and other fibre characteristics and biological factors.

(1) *Fibre Length*: It has been pointed out that the derived relationship between pressure and volume does not include the length of the fibres. By compressing different lengths of the same sample, independence of length has been established for staple lengths down to one inch, where the resistance to compression shows a tendency to diminish. It is obvious that the bending units are not the complete fibres but the elements of fibre between adjacent contacts with other fibres, and the resistance to compression consequently depends on the total length of fibre present, and not on the fibre length, down to a point where the number of free ends becomes comparable with the number of contacts.

(2) *Fibre Thickness*: The derived relationship is independent of fibre thickness for a given quantity of wool. Experimentally no correlation has been found between resistance to compression and fibre thickness. Fibre thickness is, however, correlated with the number of crimps per inch, and when the effect of the crimping is eliminated, a significant partial correlation coefficient of +0.43 is obtained between resistance to compression and fibre thickness. Either the fibre thickness has a positive effect which is masked by the crimping, or fibre thickness is correlated with other factors which do influence resistance to compression.

(3) *Number of Crimps per Inch*: A highly significant positive correlation coefficient is found between the resistance to compression and the number of crimps per inch. The crimping may have a real mechanical effect on the compressibility in several ways, or the crimping, like the fineness, may be correlated with other factors which influence the resistance to compression.

Now the resistance to compression is found theoretically to be proportional to the modulus of flexural elasticity, and the correlation coefficients found suggest that the fibre thickness and crimping are correlated with elasticity. Barker and Norris have compared the growth of wool fibres with the crinkling of a strut, and have derived a relationship between the product (number of crimps per inch) x (square of fibre diameter) and the *inverse* square root of Young's modulus. According to the results of compressibility measurements this product should, however, bear a *direct* relationship to Young's modulus.

An important result from the viewpoint of production practice is the finding that for wools whose fineness and crimping agree with Duerden's standards, the resistance to compression

increases with the quality number. Wools which are finer than the crimps indicate have a lower resistance to compression than wools which are coarser than the crimps indicate.

(4) *Harshness*: Fibre thickness was found to be the main factor in determining the harshness of two sets of samples as subjectively estimated by a number of wool experts. The resistance to compression and the non-wool fleece constituents were less important, though definite, factors. The surface friction also plays a rôle, for the increased harshness of alkali treated wool was found to be due to an increase in the surface friction. The effect of fibre thickness may be explained by the fact that wool during handling is usually in the form of a staple or in the form of a top where the fibres are more or less parallel, while compressibility measurements have to be performed on a teased out mass in which the fibres are orientated at random. This orientation cancels out the effect of fibre thickness, whilst the bending resistance of a bundle of parallel fibres depends on the fourth power of the fibre diameter.

(5) *Clean Yield of Fleece*: There is a highly significant negative correlation between the resistance to compression and the clean yield of the fleece. There is also a highly significant negative correlation between the percentage yield and the number of crimps per inch, and no correlation between percentage yield and fibre thickness.

(6) *Sex of Sheep*: In the classing and selection of rams, prominence is given to a subjectively estimated wool property known as "substance", which, in part at least, is determined by the resistance to compression of the clean wool, and there is a widespread impression that wool from rams has more "substance" than wool from ewes and wethers.

In the case of two flocks in which selection for "substance" had not been practised, no difference in the average compressibility of wool from rams and ewes could be found.

III. The Rôle of Compressibility in South African Merino Wool Production.

It is probable that the relationship between resistance to compression, fibre thickness and crimping is one of the most important factors in existing wool practice, and hence in breeding, as the following examples will show.

In the practical estimation of fineness it is assumed that a relationship exists between the fibre thickness and the number of crimps per unit length, so that the crimping forms the main basis of fineness estimation. In a random selection of 1,000 South African merino wool samples Bosman found that 72% of the samples showed a divergence from the average relation between fineness and crimping, and consequently concluded that

the estimation of fineness by means of the crimps alone would be in error in 72% of cases. On the other hand, wool experts usually handle wool in order to estimate its "quality", and consider themselves justified in classing all harsh handling wools down, and vice versa. Whether the resistance to compression or the harshness, or both, are involved in the handling, a high value of either property will, according to the relationships found, indicate too coarse a fibre for the crimping, and vice versa. It is thus seen that the handling of wool in classification serves to correct for the errors in the visual estimation of fineness caused by variations in the fineness-crimping relation.

Another result of the relationship between the fineness, crimping and resistance to compression is its bearing on the property known as "substance". According to definitions given by practical woolmen it may be concluded that this property is determined by the three factors, (i) resistance to compression, (ii) quantity and quality of the yolk, i.e., grease and suint, and (iii) the size and density of the staple.

In breeding for substance, if the breeder is influenced by the resistance to compression, he will tend to breed a coarser fibre than the crimps indicate, although he may not be conscious of the fact unless he employs means other than the crimping to estimate the fineness of the wool. It will be his policy to cull rams deficient in this attribute, and the rams retained will bear fleeces which *on the average* have a higher resistance to compression than those of the ewes and wethers. Experimental results fail to reveal a difference in this respect between the fleeces from rams and ewes in flocks where no selection for substance has been practised. The impression that fleeces from rams have more substance than those of ewes may thus simply be due to the fact that in practice most rams have been selected at least partly for this attribute.

Furthermore, if the rams retained by the breeder have fleeces with a higher average resistance to compression than those of ewes and wethers, the correlations found suggest that their fleeces will also have a coarser fibre than the crimps indicate, compared with unselected material. This is a possible reason why Bosman and Botha found that wool from stud rams was approximately two classes coarser than was indicated by the crimping, whereas Bosman found an average agreement in his random selection of samples.

If the breeder, in aiming at substance, is influenced by the yolk, of which the grease is the predominating constituent, he may obtain a misleading impression of the resistance to compression and the density of the fleece. A high correlation between greasy fleece weight and scoured fleece weight exists within a stud, so that breeding for a heavier greasy fleece will result in an increase in the scoured fleece weight. When, how-

ever, the breeder in aiming at substance and density, is misled by the grease and other impurities, he may reduce the percentage clean yield of the fleeces and so to some extent nullify his attempts at a higher clean wool production per sheep.

The negative correlation coefficient found between the clean yield of the fleece and the resistance to compression of the wool suggests that when the breeder, in aiming at substance in the fleece, is to some extent influenced by the non-wool impurities, he nevertheless tends to produce wool with a high resistance to compression. Alternatively it may be asked whether the correlation found may not be the direct result of breeding for substance, where both the amount of the non-wool portion of the fleece and the resistance to compression of the wool have been increased simultaneously.

No correlation is found between the yield of the fleece and the fibre thickness, a result differing from the findings of certain overseas investigators. A highly significant negative correlation has, however, been found between the yield and the number of crimps per inch, showing that the *apparently* fine wools have a lower yield than the *apparently* coarse wools. Since the practical estimation of fineness depends to a large extent on the crimping, the question arises as to whether the correlation found has been introduced by breeding. For, in aiming at substance, the breeder may tend, firstly, to produce wools with a high resistance to compression, i.e., wools having a coarser fibre than the crimps indicate, and, secondly, low-yielding wools. He may consequently introduce a negative correlation between yield and number of crimps per inch, and remove a possible correlation between yield and fibre thickness. At the same time he regards the crimping as an indication that he is maintaining a reasonable fineness of fibre, which may not be the case.

Now softness of handle, usually associated with "quality", is a desirable property, and it has been shown to be associated with a fine fibre or a low resistance to compression. The attribute of "substance," on the other hand, has been associated with a high resistance to compression, which requires either a coarse fibre or a fine crimping. The question arises as to how these two apparently conflicting attributes are to be combined in a single fleece.

It has been shown that for wools whose fineness-crimping relation conforms to Duerden's standards, the resistance to compression increases with the quality number. Since the harshness is determined largely by the fibre thickness, the increase in resistance to compression with quality number is not accompanied by an increase in harshness. At the lower end of the range of quality numbers, however, the effect of the fibre thickness in enhancing the harshness must be offset by a low resistance to compression, and the desired substance must be attained

by other means. Ordinarily this is not produced by an increase in the grease content of the fleece, as shown by the negative correlation between yield and resistance to compression, although it is a possible method. The third factor, viz., the size and density of the staple is probably employed, especially as one definition of substance states that it is indicated by " fullness of handle ".

The possible implications of breeding for substance, viz. a coarser fibre than the crimps indicate, with the consequent difficulty of estimating the fineness, the tendency towards harshness, and an excessive amount of grease, can hardly be considered desirable. Breeding for substance may therefore be considered as of rather doubtful value. For a sheep of a certain size, the density of the fleece will be reflected in the clean wool production per unit length of staple, and provided the latter is satisfactory, and the fleeces do not open up on the sheep, breeding for the attribute of substance would seem to be superfluous, and in some respects even undesirable.

An attempt has been made to show some implications of the subjective judgment of fleece characteristics. Hand and eye methods have met with a high degree of success in the past, and are responsible for the present standard of South African merino stud animals, but it is becoming increasingly evident that their effectiveness is approaching its useful limit. A plea for recording in stud breeding has been made on several occasions, and there are indications that the breeders themselves are considering the matter. While support must be given to such a scheme, too much emphasis cannot be laid on the need for the exact measurement of fleece characteristics. Exact measurement in recording will not only be of immense value to the stud breeder himself, but will also aid the farmer in purchasing rams. The stress sometimes laid by breeders on " substance " and " bulk ", as evidenced by such sayings as " substance fills the bales ", is definitely misleading to the purchaser of rams, for too often the " substance " referred to is merely an excessive amount of grease, for which the farmer receives no compensation as he is paid according to clean wool content, and for the production of which the sheep have to be fed.

Twelve years ago the Department of Agriculture inaugurated a free fleece testing service for breeders and farmers, and this has now been extended to two institutions. It is essential for the welfare of the South African wool industry that all stud breeders should make the fullest use of this service.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 195-202, July, 1947.*

TRIBULUS TERRESTRIS, CONTENT OF ASSIMILATES, GLUCOSIDE AND NITRATES UNDER DIFFERENT EDAPHIC CONDITIONS

BY

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Read 3rd July, 1946.

Feeling that a soil factor, leading to a disturbance in the metabolism of *Tribulus terrestris* might actually be the cause of Dikkop, beds were established in the Veld Reserve at Fauresmith, consisting of soil from Kotjes Kolk in the Calvinia district, noted for its dikkop, and from Waagkop and Leeuwfontein in this district, also noted for dikkop to a lesser degree. These soils were sown with seeds of *T. terrestris* of Fauresmith, in order to have the product of these different soils grown under the same meteorological conditions. I may mention that except for a few isolated cases last November there has been no dikkop outbreak in this district since 1933.

As it also seemed probable that the sugar content of Tribulus had some connection with dikkop, an investigation was made of the direct assimilates of *T. terrestris* under different physiological conditions, fresh, temporarily wilted and completely wilted. These analyses were made on plants growing at Fauresmith on different Karoo soils.

There are many graphs available showing the changes in assimilates of Tribulus of Fauresmith soil since 1943. The ordinary graph of the assimilates of *Tribulus terrestris* does not show anything striking except that the starch content of the stems is high.

The sugars are in the usual proportion, very little glucose, about 5-10 times more fructose and often more sucrose than reducing sugars. The fruits are particularly rich in sucrose. Wilting has a far-reaching effect, the starch in the leaves disappears very quickly, and for quite a time the sucrose content of all organs is about six times as high as the content of reducing sugars. In a later stage sucrose decreases as well. This holds good for practically all our experiments, the exceptions are the data from the bad dikkop outbreak of Oranjezicht in December, 1945, where most of the sugar present was reducing sugar and much starch was present. The Tribulus is grown on Kotjes Kolk soil, Fauresmith Veld Reserve. The difference from wilting lucerne is the prolonged stage of predominating sucrose. (This Journal, XLI, 211-212; Graphs 4-4c; Henrici, 1944.)

As the drought which started in 1944 persisted in 1945 nothing happened in the beds until February, 1946, when it was possible to take parallel samples of Tribulus for a 30 hour experiment from Kotjes Kolk, Fauresmith Reserve and Leeuwfontein soils. Waagkop soil produced but little Tribulus, although the whole veld at Fauresmith consisted at this time of Dubbeltjies. From November, 1945, onward there was a heavy dikkop outbreak between Philippolis and Colesberg on the farm Oranjezicht, 60 miles from Fauresmith, and I collected Tribulus there twice whilst the sheep were dying all around. This material was not killed with alcohol but taken to a refrigerator and later crushed in a mortar and extracted with ice-cold water. The extract foamed like beer and by beating with glass rods an active foam was obtained 5 c.c. of which haemolysed a 2 per cent. defibrated blood, in less than a second, and gave the saponin tests under the microscope. A positive reaction could be obtained for 45 minutes after which it became negative. A second fresh solution behaved similarly, action ceasing in 45 minutes. Fortunately the material or haemolytic factor in the plant in the refrigerator did not deteriorate as quickly as its water solution, although the foaming decreased from day to day. Finally I extracted first alternately with ether and alcohol, after making sure that the two solvents did not extract the factor. Then I extracted with water containing 0.9% Na Cl in which the factor is readily soluble. Different portions of the water extract were treated with normal and basic lead acetate, the factor was not absorbed by normal lead acetate, but by basic lead acetate. The lead acetate solution treated in the cold with H_2S, yielded a still active filtrate. The activity tests were done this time with blood solutions, as haemolysis was easier to see, and with H_2SO_4 under the microscope but not on gelatine as in the earliest test in 1945. I kept all precipitates and rejected filtrates as I realised that I was constantly losing material from the factor.

A second portion of the water extract I ran through a $Mg(OH)_2$ column and eluted with 50% alcohol which as I later confirmed, extracts the factor. The $Mg(OH)_2$ absorbs many disturbing substances and the alcohol extraction after evaporation in vacuum without heat, and being taken up with 0.9% NaCl was very active, only there was so little of it. Absorption on $Al(OH)_3$ with talcum and salting out for the remains of chlorophyll proved a failure. The addition of cholesterine inhibited the haemolytic reaction. Filter paper with a cholesterin barrier (Klein III/2, II, p. 1105) hung in the solution and if boiled afterwards in xylol, and washed in ether gave haemolysis. I still thought that I had to do with a saponin which was unstable in any heat. Seeing that even my plant material was deteriorating, I extracted the whole with alcohol and ether and then made a water extraction and evaporated to a syrupy consistency at

a low heat on the waterbath. I lost much, but had enough left to do some tests.

Brady's and Legal's tests were then tried as I had all my mother liquors and precipitates. Both tests are for the carbonyl group C=O, the Legal's test particularly for the aglygon of glucosides, cardiac glucosides, and the double bond in the lactone ring. Tribulus growing on the different soils established in the Fauresmith Reserve, was tested either fresh or wilted or from storage, but the two tests did not often agree, Brady's much oftener giving positive results, and the relative material also giving positive results for haemolysis.

Positive results from tests with Dinitrophenyl hydrazine were obtained with all material from Oranjezicht, Kotjes Kolk and Leeuwfontein and from some samples of Waagkop, and negative tests with Brady's reagent were obtained from all fresh samples from Fauresmith Reserve soil and from some Waagkop soil. A few microscopic crystals were obtained with Brady's tests from wilted Tribulus, Fauresmith Reserve soil, and macroscopic crystals from the Kotjes Kolk and Oranjezicht samples. Four different crystals from Fauresmith Reserve Tribulus could be identified under the microscope. Large spider-like red crystals, small coral-like red crystals, yellow six-angled needles arranged in stars and most commonly robust dentated thin red-yellow plates arranged in aggregates are forms that constantly recurred, particularly the plates. The robust crystals had definitely two melting points, the coral-like crystals melted mostly at 48° C, but on some days at 96° C. The spider and feathery plates melted mostly at 87° C,, but on some occasions between 145° and 153°, and on others, particularly in cold weather, between 48° and 58° C. The crystals were not stable and generally disappeared in 20 minutes. There was nothing like these yellow star or feather crystals in the Tribulus solution, from Fauresmith soil. The main point for the time being seems to be the existence of red-yellow crystals in Tribulus which was actually poisonous or came from soils which produce poisonous Tribulus.

The Legal test was positive in all material from Oranjezicht and from Kotjes Kolk soil, the colour was red-brown, changing to a beautiful amethyst blue in CH_3COOH and fading in mineral acids. For control purposes the Legal test was made on Radix Quillaja and on so-called pure saponin, Radix Quillaja gave a pure yellow colour, green in CH_3COOH, but the so-called pure saponin was negative. It may be mentioned that the $Mg(OH)_2$ columns previously referred to, eluted once more with 0.9% NaCl, gave the same brown red or deep yellow colour with Legal's solution, the colour changing to violet and blue-green in CH_3COOH. All solutions which had been for any length of time on the waterbath scarcely showed the reaction, only those worked

with in the cold were positive. No fraction of alcohol extract of stored Tribulus from Leeuwfontein, Waagkop or Fauresmith Reserve showed positive Legal's, although the water extract of Leeuwfontein Tribulus was slightly positive, contrary to the Brady's test which could be found macroscopically positive in the fractions for 50% alcohol downwards in Leeufontein, and in traces in the higher percentages of alcohol.

The Tribulus season, especially in a drought, is very short, outbreaks seem to coincide with the holidays and the material deteriorates hourly. What has been established is that: A substance in the poisonous Tribulus and in Tribulus from suspected soils contains an unstable water soluble substance which causes effervescence and haemolysis. The haemolysis may be stopped by the addition of cholesterin. The substance is not soluble in ether and xylol, and in fresh condition non soluble in 96% alcohol, gives positive Brady's and Legal's tests and gives positive tests for saponin with H_2SO_4. It can be precipitated with basic lead acetate out of a watery leaf extract, but not with normal lead acetate. According to the old nomenclature this would indicate a neutral saponin. According to new literature the Legal test being positive, some chemists are inclined to put this factor in the group of cardiac glucosides (Fieser).

Still according to Kofler's nomenclature, Kobert was presumably the first and only one to foresee the possibility of a saponin-like glucoside taking the place of starch under unfavourable climatic conditions. The possibility of saponins as reserve material was presumed by several older authors (Sieburg, Kofler and Kobert). It may be remembered that in all the wilting experiments—even if an increased respiration is accepted—the sugars present do not correspond to the amount of the disappearing starch (Henrici 1944) and that another product is most likely formed. It is likely that conditioned by the soil factor, zinc deficiency, this saponin-like glucoside is formed. From the experiments at Fauresmith on the different soils side by side under the same climatic factors, it is obvious that the soil factors are responsible for the production of glucoside and not the climate.

Although the work is far from complete I trust there is sufficient evidence that a glucosidic very unstable factor occurs in Tribulus on certain sandy soils under high illumination and dry air conditions, which is not present in Tribulus on ordinary chocolate-brown Karoo soils.

NITRATE CONTENT OF TRIBULUS SPP. The high nitrate content of *Tribulus spp.* was mentioned by previous writers (Rimington and Quin, 1933) but as the Fauresmith *T. terrestris* showed little nitrate (Henrici, 1938), it was thought desirable to study the subject further. It was realised that the varying amounts of NO_3 recorded could be due to a different time of the day for

sampling. From older literature, e.g. (Czapek, 1921, p. 297 ff.), three points are clear: (a) that there are plants which contain a considerable amount of NO_3, not Ammonium salts; (b) that leaves are generally poorer in NO_3 than roots and stems; (c) that the NO_3 content is likely to show changes during 24 hours, as the leaves use the NO_3 for the formation of protein in the presence of sugars. The last fact would definitely lead to a decrease of NO_3 in day time in the leaves. Protein, however, can also be formed in the dark from sugar and NO_3, but the process goes much slower.

As *Tribulus terrestris* from different soils was available under identical climatic conditions at Fauresmith, samples could be taken every few hours during a period of 30 hours to get the daily curve of NO_3 in the different organs of the plant; to compare the different contents of NO_3 on the different soils; and to solve the point whether the pre-treatment with alcohol and ether of Tribulus extracted afterwards with water containing 0.9% NaCl destroyed the enzyme reducing the nitrate to nitrite.

METHOD: The method used for qualitative tests for nitrate was the usual diphenylamine (Molisch, 1923, p. 89). For the quantitative tests several methods were tried, the precipitation with Nitron (Treadwell and Hall, II, 1924, p. 39), the method of Strowd (1920) and finally the method of Shive and Session (1928), as adapted by American physiologists for plant work. Only the last method was satisfactory under our conditions. The principle is that NH_3 is determined from a plant extract which is treated with Sodium carbonate and NaCl, and afterwards with Devarda. An air current is drawn through the bottles for 12 hours for each treatment. With our own apparatus it proved easier to put simultaneously a bottle A with Na_2CO_3 plus NaCl and a bottle B with these reagents plus Devarda plus 5 c.c. of 6% sodium hydroxide and the two absorption tubes in the same current, as consecutive supervision for 25 hours could not be arranged. The NH_4OH found in the Devarda absorption tube minus the NH_4OH found in the carbonate absorption tube corresponds to the NO_3 in the plant extract. Our pumps permitted 12 bottles to be drawn at one experiment, parallel arrangement being preferable to serial arrangement. Capryl alcohol and paraffinum liquidum and ice cooling were used against extensive frothing; no heat being used for the determination. Duplicates obtained were very good and KNO_3 added to the plant extracts was always quantitatively obtained. The apparatus requires constant supervision, particularly during the 3rd hour, but the results obtained after some practice are excellent. Titration was done with 0.05n—H_2SO_4 and diluted KOH or NaOH—0.033n being recommended. If larger amounts of NO_3 are present, 0.1n—H_2SO_4 and alkali can be used. Leaves, roots and stems were tested separately after having been ground

on hammer mills. Material for the daily curve was sampled five times during the 30 hours and killed in the veld in alcohol.

Results: The following is the daily course for the NO_3 content of *Tribulus terrestris* from Fauresmith. It appears that in day time the NO_3 content of all organs is very small, while in the early morning there is more NO_3 in leaves and stems. The roots always have only a little NO_3. The aerial organs have an early maximum value and contain more NO_3 during the night than in the day time.

Other single values of leaves, stems and roots are tabulated in Table I. The high values for NO_3 obtained at Onderstepoort in 1933 were probably from material collected during the day.

All things being equal there seems to be a tendency for wilted Tribulus from Fauresmith soil to have more NO_3 than fresh Tribulus in day time. This seems quite logical, as presumably in the fresh plant the NO_3 is continuously used for the formation of protein, the carbohydrates being provided by photosynthesis. Wilting decreases the assimilation of CO_2 and the formation of the necessary carbohydrates for the building of protein, thus NO_3 can accumulate. On the other hand during the first phase of wilting, sugars are formed by the hydrolysis of starch present and complete stoppage of protein formation is doubtful.

The NO_3 content of Tribulus of Fauresmith cannot be regarded as the product of a plant storing NO_3 but it is possible that this may occur under other climatic and edaphic conditions. The formulation (Czapeck, 1920) that stems and roots contain more NO_3 than the leaves cannot be confirmed as the smallest amounts of NO_3 were hitherto found in the roots.

The second question from a Chemical aspect was whether the presence of nitrate, by reduction to nitrite, would break down methaemoglobin and thus interfere with the haemolysis tests. The aqueous or the sodium chloride extract usually produced a brown colour after a few minutes; if, however, the material was first extracted with ether and alcohol and the aqueous extract kept at 0° C., the latter gave no brown colour with the blood. The aqueous extract still contained nitrate (except frequently in the case of leaves collected between 12 noon and 2 p.m.) but no nitrite was present. A positive test for nitrite, using the Griess reagent, was obtained only when the extract was purposely allowed to deteriorate at room temperature for 72 hours; apparently an infection of denitrifying bacteria took place some days after the enzyme was destroyed. Extracts with pure water of material from Leeuwkop and Calvinia soils, when such material was not pre-extracted with organic solvents, showed no nitrite after 24 hours, but similar extracts of ordinary Fauresmith plants which were also rich in nitrate gave a positive Griess reaction for nitrite after 24 hours (Klein, p. 79). This

may possibly be an indication that the plants on the suspected soils have a more active peroxidase system than the plants on Fauresmith Soil preventing reduction of nitrate in the former.

The above work indicates that nitrate will not interfere with haemolysis tests if the material, as in the present case is previously treated with organic solvents to remove fats, chlorophyll and other colouring matter; not only does the alcohol extract some of the nitrate but apparently the alcohol and ether extractions destroy the enzyme which reduces nitrate to nitrite. If no pre-extraction is carried out, however, there is a real danger that nitrate, reduced to nitrite, will interfere with the haemolysis test.

TABLE I.

Nitrate Content of different samples of Tribulus terrestris.

No.	Place	Date	Leaves	Roots	Stems	Fruit
3429-31	Oranjezicht	10.12.45 2.30 p.m.	0.199	0.186	0.074	
3439-41	Calvinia soil, Fauresmith	22.2.46 12 a.m.	0.203	0.134	0.062	
3442-44	Fauresmith	22.2.46 12 a.m.	0.211	0.084	1.6	
3445-47	Leeuwfontein soil, Fauresmith	22.2.46 12 a.m.	0.018	0.096	0.127	
3448-50	Waagkop soil, Fauresmith	22.2.46 2 p.m.	0.211	0.031	0.892	
3196-99	Fauresmith	27.2.45	0.23	0.1	1.76	
2828	Fauresmith	3.4.44	0.08	0.44	0.28	0.16
2682	Fauresmith	20.1.44 7 a.m.	—	—	0.407	
2489	Fauresmith	8.4.43 12 a.m.	—	—	0.09	

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THE EXTERNAL AND INTERNAL CAUSES OF THE STATIC FOOT DISORDERS.

BY

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Read 3rd July, 1946.

Abstract.

The most important external cause of all foot troubles is ill-fitting shoes, into which category fall the majority of shoes now on the market.

Dropping of the anterior metatarsal arch can develop in the longitudinal or the transverse direction, or the two may be combined. Lifting of the metatarsal arch in a transverse direction also occurs, but rarely.

Lifting of the middle portion of the arch, producing the so-called " hollow foot " is very often due to the wearing of short shoes in childhood, which gives the foot no other choice than to grow in the direction of least resistance, formed by the open part of the shoe.

Flattening of the foot does not usually commence, as is often supposed, with an outward rotation (pronation or eversion) of the os calcis; it starts in the anterior part of the foot and extends progressively backwards. The direction in which the os calcis is displaced is largely determined by the arrangement of the muscles and by the differing alignment of the tibia and os calcis. Variations in the angle of the femur and tibia at the knee, producing a tendency towards either bow-leg or knock-knee also help to determine the displacement of the os calcis.

Flat foot is partly inherited, partly acquired.

Among the internal causes of flat foot especial importance is assigned to deficiency of vitamin B1. It has been found that flat foot is commonly associated with peripheral neuritis and is among the early manifestations of the clinical syndromes due to vitamin B1 deficiency. This is borne out by the fact that flat foot and other consequences of vitamin B1 deficiency may be found associated in individuals who have a personal preference for foods lacking in that vitamin.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 204-209, July, 1947.*

THE STRUCTURE OF THE STOMACH OF THE SOUTH AFRICAN AARDVARK, *ORYCTEROPUS AFER.*

BY

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With 3 figures.

Read 3rd July, 1946.

Introduction and Literature.

The Genus Orycteropus has been one of particular interest to zoologists. Originally included in the order Edentata, Orycteropus was later found to differ from the other members of the group in many important respects, particularly in the structure of its teeth. A separate order, Tubulidentata, was created, of which Orycteropus is the only representative.

Brief references to the stomach of Orycteropus are found in the literature. As long ago as 1843 Rapp commented on the thickness of the musculature of the stomach, and Oppel (1896) mentions the simple structure of the organ. Sonntag's description (1925) is a little more detailed. He writes that " the stomach is simple and capacious and appears externally to consist of a sac with a very hard, globular pyloric region. . . . The muscular coat, which is of moderate thickness in the gastric sac, becomes greatly hypertrophied to form a kind of gizzard in the pyloric globe. . . . No septa divide up the gastric sac into compartments ". LeGros Clark and Sonntag (1926) review these data and use them to support their conclusion that, upon anatomical grounds, Orycteropus is quite distinct from the Edentates. Weber (1928) adds nothing to this description. The present study was undertaken to determine the gross anatomy and histology of the stomach of Orycteropus from favourable material.

Material, and Methods.

A single stomach of a full-grown female *Orycteropus afer* was used. The organ had been slit open, its contents evacuated, and placed in Bouin's fluid immediately after death, and preserved after fixation in 10% formalin. For the microscopical study eight blocks of different parts of the stomach wall were cut with a sharp blade, dehydrated, and embedded in paraffin. The 10μ sections, stained with haematoxylin and eosin, indicated the general arrangement of the muscle layers and the divisions of the mucous membrane. For detailed study of the cytology

of the glands, further blocks of mucous membrane alone were prepared, and the 6μ sections stained with thionin, Mallory's stain and Giemsa stain. The latter, when slightly overstained and differentiated in acidulated alcohol, was found very useful for displaying the body chief cells and parietal cells.

Gross Structure.

Figs. 2 and 3 in plate 1 are photographs of the whole stomach, and of a longitudinal section through the stomach, respectively. They show the organ as a large, elongated dilatation of the alimentary canal, having the form of two rounded sacs separated by a constricted portion or isthmus. It is 15 cms. in greatest length and 7.3 cms. in diameter, and measures 6.2 cms. along the lesser and 31 cms. along the greater curvature. The cardiac orifice, the region of transition between oesophagus and stomach, is marked internally by a distinct cardiac notch, which corresponds with the region of transition between oesphageal and gastric epithelia. Externally, the cardiac orifice is marked by a distinct groove.

Near the cardiac orifice is the first sac or fundus. This is continuous distally with the second sac or pylorus, which is easily recognised by the great thickness of its muscular wall. The pyloric orifice, where pyloric mucosa goes over into duodenal mucosa, is bounded by a well developed sphincter.

The whole stomach is invested with peritoneum, which has no unusual connections.

The muscularis is well developed, particularly in the pyloric region. The three component layers can be distinguished macroscopically. The mucous membrane of the fixed stomach is thrown into a number of large folds, which are easily seen in Fig. 3. They are chiefly longitudinal in disposition and very conspicuous in the pylorus, an observation probably related to the thickness of the musculature in the region. In addition to the larger folds, there are visible macroscopically numerous anastomosing smaller folds over the whole mucosa.

Microscopical Structure.

Sections through the wall of the stomach show the typical layers of the vertebrate alimentary tract, namely, peritoneum, muscularis, submucosa, muscularis mucosae and mucosa.

Peritoneum.—This layer has the usual simple squamous epithelium, under which is thin fibrous connective tissue.

Muscularis.—The most salient feature of the whole stomach is the great development of the muscularis, which occupies the greater part of the thickness of the stomach wall. The great development occurs in the middle circular layer. Even in the fundus region it is some 3 mm. in thickness and it becomes

progressively thicker in the pylorus, so that near the pyloric sphincter, to which it contributes fibres, it is well over 2 cm. in cross section. Another noteworthy feature is the division of the circular muscle into bundles by strands of smooth muscle running obliquely through the layer. These strands are continuous with the inner and outer layers of muscularis and are so well defined in the pyloric region as easily to be seen macroscopically (Fig. 3). The outer longitudinal muscularis is not well developed. It clothes the middle layer and is somewhat thickened to form bands of fibres running round the extremities of the organ and continuous with the outer muscularis of the oesophagus on one hand and the duodenum on the other. The inner oblique layer of muscularis is present throughout the stomach but is not well developed in any region.

Submucosa.—The connective tissue of the submucosa is rendered conspicuous by the presence of many mast cells. These stand out well in Giemsa sections because of the deep basic staining of their granules. In the presence of mast cells in the submucosa, the stomach of Orycteropus resembles fishes and some higher vertebrates, e.g. Elephantulus.

Muscularis mucosae.—The muscularis mucosae forms a well-defined layer, from which smooth muscle fibres project into the ridges of mucous membrane.

Mucosa.—The mucosa is of particular interest. In addition to the larger macroscopically visible ridges, it has many smaller folds, not unlike intestinal plicae, each with a central muscular core and with connective tissue, glands, pits and surface epithelium on either side. The lamina propria connective tissue has very few lymphoid cells. There is no aggregation of lymphocytes at the cardio-oesophageal junction, as occurs in man and many other vertebrates. The epithelium of the stomach is invaginated in the usual fashion into gastric pits. Into these the glands open. The glands are supported by a delicate framework of reticular connective tissue.

The Gastric Glands.—The gastric glands are for the most part simple tubular structures, branching only near their bases. On the basis of the gland types, four regions of mucosa can be distinguished, as indicated in Fig. 1.

The region of cardiac glands is narrow, being only 7 mm. in section. In having so narrow a cardia, the stomach of Orycteropus resembles the stomach of man. The cardiac glands are branched tubular structures which occupy the entire mucosa from immediately next to the oesophageal epithelium to the region of fundus glands.

The region of fundus glands occupies about one-half of the whole surface of the stomach. The glands themselves branch near their bases, filling the whole region between surface epithelium and propria. The neck region is characterised by the

presence of mucous neck cells, many parietal cells and a few chief cells. Nearer the base of the gland mucous neck cells do not occur, parietal cells are few and the great bulk of the tissue is made up of chief cells.

The pyloric glands are identical in appearance with the cardiac glands. Near the region of transition between fundus and pylorus, some parietal cells occur in the pyloric glands. Otherwise the cells of pyloric and cardiac glands are similar in type to the mucous neck cells.

Cytology of the Gastric Epithelium.

Surface Cells.—The surface cells are tall columnar elements lining the surface of the gastric mucous membrane and the pits which open into it. They have rounded or oval basal nuclei and stain metachromatically with thionin, indicating a mucous type of secretion.

Mucous Neck Cells.—The mucous neck cells are columnar epithelial elements. They are, at the junctional region, not readily distinguishable from the surface cells, being taller than the corresponding elements in the stomach of man. They have rounded or somewhat basally compressed nuclei and a mucous type of secretion.

The Body Chief Cells.—The body chief cells, of which comprise the greater part of the fundus glands, are columnar elements with round, chromatic, basal nuclei. They are readily distinguished by the staining properties of their zymogen secretion. In Giemsa sections the secretion in each cell stands out as a conspicuous mass of dark purple rounded granules of variable size, quite different from the red-stained granules of the parietal cells. The chief cell granules stain with the Orange-G component of Mallory's stain. The Giemsa and thionin sections show, in addition to the secretory granules, diffusely blue-staining chromidial substance in the basal third of the cells.

The Parietal Cells.—The parietal cells are most numerous near the necks of the glands, where they are related to both the mucous neck cells and the body chief cells. The parietal cells are easily distinguished from the body chief cells by their rounded or triangular shape, peripheral position in sections through acini, absence of chromidial substance, and by the different staining of their granules. The granules of parietal cells are eosinophilic in Giemsa sections, and stain violet with Mallory's stain. In between the groups of granules the intracellular canaliculi, described in other animals, can be distinguished. The round, chromatic nuclei of the parietal cells are more or less central in position. Binucleate parietal cells are rare.

No basal granular cells could be distinguished in the available material.

Comment.

The stomach of Orycteropus has the following characteristic features:

(*a*) A well-developed muscularis, chiefly due to the large size of the middle circular muscular layer. It is particularly strong in the pyloric region.

(*b*) The submucosa is characterised by the presence of numerous mast cells.

(*c*) The mucosa is divisible into cardiac, fundus and pyloric regions, as shown in Fig. 1, each with its own gastric glands. The cardia is a narrow zone near the cardiac orifice and the fundus and pylorus each occupy about one-half of the remaining surface of gastric mucous membrane.

From the above description it is clear that the stomach of Orycteropus, unlike that of the Edentates, has no keratinised epithelium or other specialised features. The evidence is presented to show that, so far as the morphology of its stomach is concerned, Orycteropus is quite distinct from the Edentates. The stomach of Orycteropus has a fairly generalised mammalian pattern, not unlike that of man and the pig. Its thick musculature is, however, distinctive.

Acknowledgments.

I wish to thank Professor Raymond A. Dart in whose department this work was carried out, and Mr. D. S. Dry for help in the preparation of the material and photographs. I am particularly indebted to Professor C. J. van der Horst for supplying the material and to Dr. J. Gillman for his help, advice, and constructive criticism throughout the period of research.

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EXPLANATION OF FIGURES.

Fig. 1.—Longitudinal section of stomach of Orycteropus, indicating the distribution of the gastric glands.

Fig. 2.—Photograph of whole stomach.

Fig. 3.—Photograph of internal aspect of stomach wall.

ABBREVIATIONS.

C O—cardiac orifice, C N—cardiac notch, G C—greater curvature, I M—inner layer of muscularis, L C—lesser curvature, M M—middle layer of muscularis, O M—outer layer of muscularis, P O—pyloric orifice, P S—pyloric sphincter.

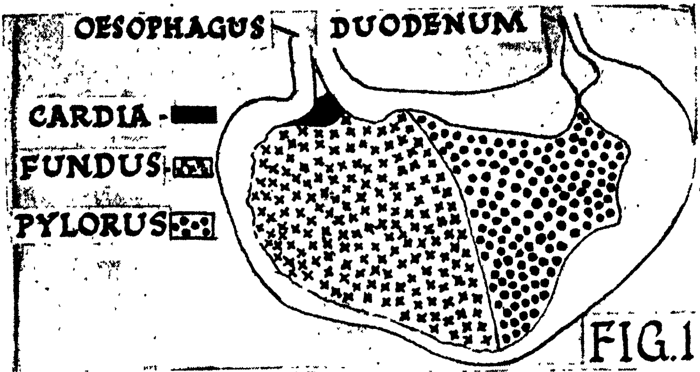

FIG.1

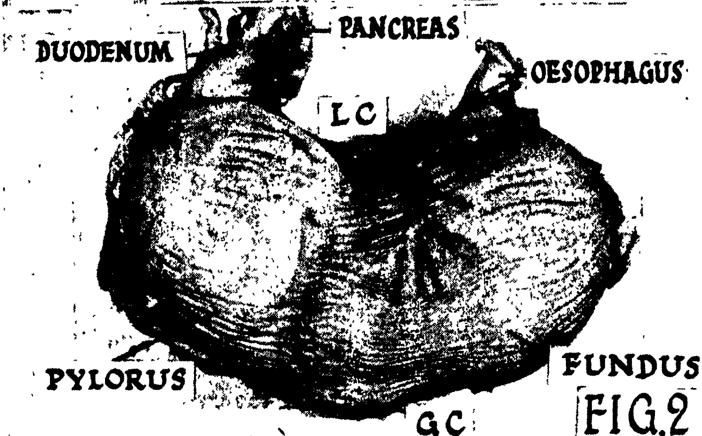

FIG.2

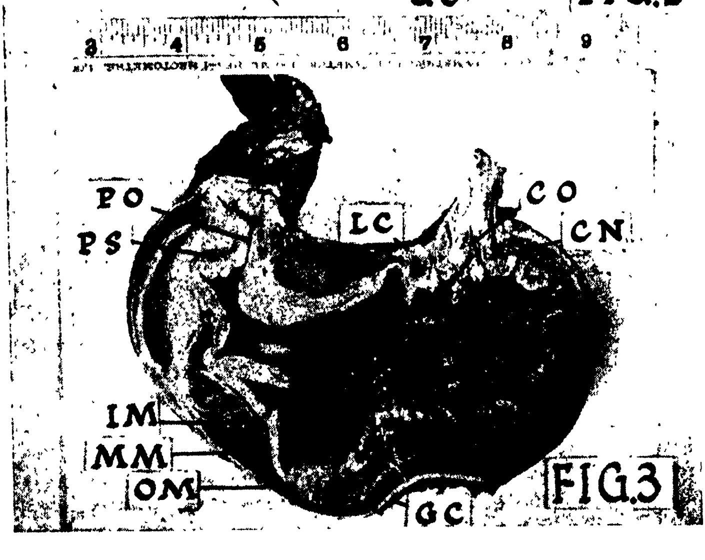

FIG.3

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 210-212, July, 1947.*

THE NEED FOR THE CHARACTERISATION OF ALL THE GERMINAL CELLS.

BY

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Read 3rd July, 1946.

In the past, investigators of spermatogenesis distinguished four types of germinal cells—spermatogonia, primary spermatocytes, secondary spermatocytes and spermatids. These cell types were described, and their relation to the first and second meiotic divisions was elucidated by much careful cytological and cytogenetical work.

The emphasis placed on the study of the meiotic divisions diverted attention from those aspects of the differentiation of the germinal cells not related to meiosis. In this way the names applied to each of these so-called cell types were in reality names designating classes of cells. The divergences in structure existing between various members of any one class could sometimes be much greater than between those of two different classes of cells.

Although the morphology and metamorphosis of spermatids have been carefully characterised by investigators, little attempt has been made to elucidate the factors responsible for the remarkable transformations of the spermatids into the fully differentiated spermatozoa.

The behaviour of the secondary spermatocyte does not constitute an immediate problem for the cytologist. All the reactions known to occur in these cells are accomplished within a very short period of time.

However, when the classes of primary spermatocytes and spermatogonia are considered, it can be seen that the inadequate characterisation of all the cells of these classes has been partly responsible for the lack of knowledge concerning the factors controlling the differentiation of these cells. Insufficient importance has been placed on those well-marked differences known to exist between the members of these two classes of cells. Moreover, the delimitation between spermatogonia and primary spermatocytes has not been accurately established. This problem has therefore not been fully enunciated, and this has prevented an understanding of the factors controlling that differentiation.

As an example of the confusion which exists in this field, I quote the following passages from Maximow and Bloom's Textbook of Histology (1939):

> "With the completion of the last spermatogonial division the period of growth starts and each spermatogonium gradually increases in size and its nucleus undergoes marked transformations."

and

> "The changes undergone by a spermatogonium developing into a primary spermatocyte (period of growth) represent a gradual preparation for the meiotic divisions and the reduction of chromatin."

From these statements it is not possible to ascertain when a spermatogonium becomes a primary spermatocyte. Consequently there is no need, on this basis, to investigate the factors which produce such a change. In order to expose the various problems associated with dynamics of proliferation and differentiation of the cells, it has been found necessary to re-define the cell types in the testis.

1. The class "spermatogonia" is defined as including those cells still capable of undergoing mitotic division.
2. The class "primary spermatocytes" is defined as including those cells which arise after the last mitotic division of the spermatogonia and become transformed after the first meiotic division into secondary spermatocytes.

If then, the cells in the seminiferous tubules can be oriented in temporal relation to the last mitotic and first meiotic divisions, the characterisation of all the members of each class will be possible.

In the rat, so-called spermatogonia are first seen seven days after birth; primary spermatocytes in the diplotene stage of meiosis can be identified 20 days later; and spermatozoa are differentiated 48 days after birth. Thus the time taken for the spermatogonia to be transformed through all the intermediate stages to the fully formed spermatozoa is almost 7 weeks. By taking advantage of this slow differentiation it becomes relatively easy to characterise all the distinctive cells which appear during spermatogenesis and spermiogenesis. All these cells can be related in time as well as morphologically to meiotic divisions.

At birth the spermatogonia have large round nuclei containing a fine chromatin network and two or three large round nucleoli: these cells have been called primordial spermatogonia. They differentiate into the spermatogonia which can now be named interphase spermatogonia. These cells have round or oval nuclei, with one or two small blocks of chromatin applied

to the nuclear membrane, and the remaining chromatin aggregated into a large mass lying in the centre of the nucleus. Finally there is the striking cell type B of Allen (1918), which I have designated by the name of premeiotic spermatogonium. The round nucleus of this cell contains blocks of chromatin plastered against the nuclear membrane.

In the class of primary spermatocytes, the earliest and latest members have not the same characteristic structure. The earliest primary spermatocyte has a small oval or round nucleus, which contains many large blocks of chromatin interspersed with numerous fine chromatin granules. The latest primary spermatocyte is a cell in the diplotene stage of meiosis, with the loops and chiasmata in the chromatin threads characteristic of this form. Connecting these two extreme types of spermatocytes are a continuous series of intermediate cells, which can be easily divided into four types.

The primary spermatocyte class, then, consists of at least six easily recognisable members, the first of which does not resemble the various members of the class of spermatogonia. Three distinct major landmarks can be distinguished between the emergence of spermatogonia and the fully formed spermatozoa. These are the last mitotic and the first and second meiotic divisions. Each landmark as well as the cells between these landmarks emerge at relatively constant periods after birth in well-fed rats.

In this way the need for the characterisation of all the germinal cells has been emphasised, and the delimitation of the classes into which these cells can be placed has been shown to be of importance in enunciating and defining the problems of spermatogenesis and spermiogenesis.

Acknowledgments.

My thanks are due to Professor R. A. Dart, in whose Department this investigation was carried out. This work was done under the direction of Dr. J. Gillman to whom I am indebted for valuable advice and criticism.

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THE STATUS OF THE BLACK WILDEBEEST *CONNOCHAETES GNOU* (ZIMM.) IN THE UNION OF SOUTH AFRICA.

BY

R. BIGALKE,

Director of the National Zoological Gardens.

With one photograph and one table.

Read 4th July, 1946.

The Black Wildebeest or White-tailed Gnu (*Connochaetes gnou* (Zimm.)) is a South African antelope the future of which is in the balance.

On account of its peculiar appearance and amusing antics on the veld, so well described by R. G. Cumming(6), this animal, no doubt, drew the attention of the settlers at the Cape from an early date, possibly even before the beginning of the eighteenth century.

It is generally stated that the first account of the Black Wildebeest was given by G. J. Allamand in his book entitled "Histoire Naturelle du Gnou, du Grande Gerbe et de l'Hippopotame" published in Amsterdam in 1776. But Mr. R. W. Hayman of the British Museum has drawn my attention to the fact that Allamand gave a description of the "gnou" as early as 1771 in Schneider's edition of Buffon(10).

The first scientific description of the Black Wildebeest was given by Zimmermann under the name of *Bos gnou*(14) in 1777. Mr. Hayman has kindly furnished me with a transcription of this description, and I am indebted to Dr. H. L. Gonin for the following translation from the Latin text: "*Bos gnou.*" "Let us draw attention to an animal hitherto unknown and only quite recently brought to light; in my opinion it can be placed between Linnaeus' *pecora* (i.e. even-toed ungulates exclusive of pigs) and *belluae* (beasts), or if it is preferred, between the horse and the ox, and it can certainly be included under the genus *boves,* though in a certain sense it can also be included among the horses, from which it does not greatly differ in certain respects. Our knowledge of this animal we owe to the industry and zeal of the celebrated Mr. Allamand, who gave a very good and exact description as well as an illustration of the animal under the (apparently Greek?) name 'gnou' in Buffon's Histoire Naturelle which he edited, Volume XV, page 113, illustration IV (N.B.—This appears to be a reference to Schneider's edition of Buffon, Amsterdam, 1771, to which Allamand contributed). That estimable scholar was able to do this better than anyone else, because he had the opportunity of observing at close quarters

the living specimen which is now being kept in the zoological garden of the most serene Prince of Orange at the Hague. He (i.e. Allamand) writes that the animal is as large as an ass, and adds that animals of the same kind occurring in the free state in their native country are much larger in size and more spirited in nature. Allamand had the animal measured and found that it was 3½ feet high and 4½ feet long."

"With the exception of certain parts to be named, the whole body is covered like that of a deer with short yellowish-brown hairs, the tips of which are white. It is for this reason that it seems to be of an ash-white colour. The head is not very different from that of an ox, although it is thicker; the anterior part of the head is covered with long black hair, which extends to below the eyes, and in view of the fact that pure white (?) hairs of the same length constitute the beard on the underlip, a queer and unusual appearance results; the animal's large black eyes are surrounded by rather long eye-lashes which remind one of a star out of the middle of which the eye itself sparkles. The upper part of the forehead is armed with two black horns 19 inches in length, the circumference of the base of which measures 17 inches. The horns themselves extend straight out for a distance of six inches, touch one another (i.e. at the base), and then bend upwards and taper to a point."

"At a distance of two inches from the horns there are denser hairs like a mane which extends from the upper part of the neck to the back; the basal white parts become black at the tips; the ears are situated behind the horns and are covered with shorter black hair. One may say that the back, which is evenly formed, the thighs, the posterior parts of the body and the tail, which is covered with longer white hairs, are those of a young horse. The underparts of the neck are covered with shorter hair, but the head with longer hair. The limbs have the same form and gracefulness, even the black hoofs, of a deer. In the upper jaw there are no incisor teeth, but in the lower jaw there are eight (N.B.—We now know that two of these eight are canines). Although the celebrated savant could not yet establish this with certainty, he infers from this with a great deal of probability that the animal must be included among the ruminants. Though the animal does not seem to be ferocious at first sight, yet, when touched, it threatens to tackle with the horns those that come too near and stroke it. Sometimes it kneels down, and while bending the head downwards it moves forward fairly quickly."

"It is stated that these animals are fairly plentiful in the interior of Africa. In view of a desire to explore Africa, Gordon, a Dutch officer, travelled from the Cape of Good Hope to the Tropic of Cancer and met with large herds of these animals. Allamand suspects that they inhabit the interior of Africa, Ethiopia and other neighbouring territories."

"It is probable that the animal obtained the name gnou from the Hottentots on account of its voice, though it sometimes also bellows like cattle and gives vent to a sound like the voice of a heron. It lives on grass. Time will tell whether it is known in the kingdom of the Congo by the name of *empakassa* or *empabunga*."

"The name gnou will be found in the zoological chart of the Cape of Good Hope attached hereto."

In this description it is interesting to note that there appeared to be some doubt in Zimmermann's mind about the origin of the name "gnu".

In 1814 Lichtenstein(8) created the genus *Connochaetes* (konnos, beard; chaitê, hair, mane), owing to the fact that the Black Wildebeest differed from the genus Bos. Hence the present scientific name for the Black Wildebeest is *Connochaetes gnou* (Zimmermann).

A transcription of Lichtenstein's diagnosis of the genus *Connochaetes*(8) has kindly been supplied to me by Mr. R. W. Hayman. Translated from the German it reads as follows: "With a long tail covered with long hair throughout its length, with a well-developed mane; no dewlap, vestigial lacrymal sacs, both sexes horned. *Connochaetes* (only one species)."

The English name "gnu" has been taken over from the Hottentot name t'gnu. Sparrman(12) states that "t'Gnu is the Hottentot name for a singular animal, which, with respect to its form, is between the horse and the ox". The name is a good onomatopoeic reproduction of the animal's voice.

According to Scholtz(11) the Afrikaans name "wildebees" (Nederlands: wildebeest) dates back not later than the time of Gordon about the year 1779. The Black Wildebeest does somewhat resemble a small ox in form, and this may account for its Afrikaans name. But it may also be that the name "wildebeest" is derived from the wild antics that are so characteristic of this antelope on the veld(4).

In January of the year 1776 Sparrman (12, Vol. II, p. 175) found the Black Wildebeest to be plentiful in "Agter Bruntjes-Hoogte", i.e. the present district of Somerset East, and in 1797-'98 Barrow(3) had the same experience on the plains of Graaff-Reinet and the Middleburg (Cape) area.

In September, 1836, W. C. Harris found large troops of Black Wildebeeste on what are to-day the plains near Richmond (9, p. 34). Harris also mentions the presence of the animal north of the Vaal River., In December of the year 1836 Harris found himself in the area north of the Vet River in what is now the Orange Free State. He writes as follows (9, p. 302): "At every step incredible herds of Blesbucks and Springbucks, with troops of Gnoos, and squadrons of the common, or stripeless Quagga, were performing their complicated evolutions."

Another traveller who saw Black Wildebeeste in large numbers was Roualeyn Gordon Cumming. Early in 1844 Cumming was hunting in the vicinity of the Riet River in what is now the South-Western Orange Free State. He writes(6): "The black wildebeests which also thickly cover the entire length and breadth of the blesbok country, in herds averaging from twenty to fifty, have no regular course, like the blesboks. Unless driven by a large field of hunters, they do not leave their ground, although disturbed."

Cumming's wanderings also brought him to the Vet River in the present Orange Free State in January of the year 1849. He writes thus (6, Vol. II, p. 372): "After proceeding about a mile, I found myself out of the country of sweet grass, and entering upon bare and boundless open plains, thinly clad with sour pasturage, the favourite haunt and continual residence of innumerable herds of black wildebeest, blesbok and springbuck." And again: "I found the boundless undulating plains thickly covered with game, thousands upon thousands chequering the landscape as far as the eye could strain in every direction."

In 1899 Bryden(5) estimated the total number of Black Wildebeeste in the whole of South Africa at probably well under 600 or 700 head. But this estimate was rather arbitrary, as it was based on a knowledge of only three farms in the Orange Free State, one of which was owned by Mr. Piet Terblans, an original voortrekker of the Free State.

In order to obtain information about the present status of the Black Wildebeest in the Union of South Africa, the writer circularised a number of known owners. Other names and addresses were kindly submitted by magistrates or owners of Black Wildebeeste. The results of this investigation are shown in the attached table. As some owners have probably been overlooked and a few did not reply to the circulars, it is not claimed that the list is complete, but it can be stated that in April of the year 1946 there were approximately 1,048 Black Wildebeeste in the Union of South Africa.

The Orange Free State remains the headquarters of this interesting antelope. Excluding specimens in zoological gardens, there are only four troops outside the borders of the Orange Free State. The largest of these four, namely a herd of 204 animals, is owned by De Beers Consolidated Mines Ltd. in the district of Kimberley. Another herd of 46 animals is owned by Mr. J. J. Hoffman in the district of Wolmaranstad.

In Natal there is a troop of 17 animals (July, 1945) in the Klip River district that have their origin from four animals introduced in 1918.

In June, 1911, R. T. Coryndon (13, p. 105) reported that on the farm Kameeldoorns and the neighbouring farm Langkuil (district of Kroonstad), the latter owner by Mr. Jan Delport,

there were 1,800 Black Wildebeeste, 6,000 Blesbuck and about the same number of Springbuck. On a reserved part of Langkuil, Coryndon one morning saw about 1,500 Black Wildebeeste, 2,000 Blesbuck and 1,500 Springbuck within a mile of his cart(13). In February, 1945, there were 50 Black Wildebeeste on the farm Langkuil but none on Kameeldoorns.

Prior to the year 1936 there were no Black Wildebeeste on Crown land anywhere in the Union. It was largely due to repeated representations made by the Wild Life Protection Society that the Provincial Administration of the Orange Free State liberated five cows on the Somerville Game Reserve in October of the year 1936. A bull was added in the year 1937, and in April of the year 1939 another bull and six cows were introduced. That the animals are making good progress is shown by the fact that they had increased to 52 specimens by February of the year 1945.

Of the total number of approximately 1,048 Black Wildebeeste that survive in the whole of the Union only one herd of some 50 animals is to be found on Crown land. As recently as 1911 two farms in the Kroonstad district carried nearly twice as many Black Wildebeeste as are now to be found throughout the Union. It is obvious, therefore, that the position has deteriorated considerably in the intervening 35 years, and the question arises whether the provision made at the Somerville Reserve is adequate.

There is reason to believe that this is the first survey of its kind undertaken in the Union. Its object is twofold, viz. (1) to determine the status of a disappearing species with such accuracy as is possible, and (2) to draw attention to the necessity for similar surveys in the case of other species. It is urgently necessary, for example, to have accurate information about the present status of the Cape Mountain Zebra, the Red Hartebeest and the Knysna Elephant in the Cape Province, the Red Hartebeest and the Gemsbuck in Transvaal and the Red Hartebeest in Natal.

Recently the Administrator of the Transvaal Province appointed a Commission of Enquiry into Game Preservation with wide powers of reference. This Commission has recommended the establishment of a Provincial Game Department on a scientific basis, a step that has been long overdue. One of the functions of such a department will be to undertake surveys similar to the present one, in order to ascertain the status of dwindling species with greater accuracy. It is essential to be in possession of such information if proposals for protective measures are to carry any weight.

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BLACK WILDEBEEST IN THE UNION GRAND TOTAL, APPROX. 1048

Farm	District	Owner	Number introduced	Bulls	Cows	Calves	Total	Date of return
ORANGE FREE STATE								
Fort Bester	Bethlehem	A. J. J. Bester		0	6	0	6	Apr. 1945
Uitvlugt West	Bloemfontein	M. Kruger		25	80	25	130	Mar. 1945
	Bloemfontein	Zoological Gardens		1	0	0	1	Mar. 1945
Mahemsfontein	Boshof	J. A. du Plessis		-	-	-	App. 20	Mar. 1945
Mond van Otterspruit	Bothaville	W. A. Badenhorst		-	-	-	7	Apr. 1945
Prynnsberg	Ficksburg	Newberry Estates	About 25 in 1885. Formerly 300.	4	11	3	18	Apr. 1945
Buckland Downs	Harrismith	J. Mackie Niven	6 calves in 1904 by Sir P. Fitzpatrick.	5	11	8	24	Mar. 1945
Driefontein	Heilbron	Col. C. J. Roos		5	4	2	11	Apr. 1946
Bruintjieslaagte	Kroonstad	C. Delport		-	-	-	11	Feb. 1945
Erfdeel	Kroonstad	B. J. Wessels		1	6	0	7	Apr. 1945
Geluk	Kroonstad	Dr. G. A. Beyers		-	-		App. 250	Feb. 1945
Grootkuil	Kroonstad	B. J. Wessels		5	35	10	50	Mar. 1945
Hamiltonsrust	Kroonstad	B. J. S. Wessels		10	40	15	65	Apr. 1945
Langkuil	Kroonstad	J. L. Delport		15	35	-	50	Feb. 1945
Leeuwbosch	Kroonstad	G. Schultz		-	-	-	27	Feb. 1945
Groot Saxony	Winburg	C. J. v. Schalkwyk		4	19	3	26	Apr. 1945
Somerville Game Reserve	Winburg	O.F.S. Administration	5 Cows, Oct. 1936 ; 1 Bull 1937 ; 1 Bull & 6 Cows, Apr. 1939.	-	-	-	52	Feb. 1945
						Approx. Total	755	
TRANSVAAL								
	Johannesburg	Zoological Gardens		2	4	0	6	Mar. 1945
	Pretoria	National Zool. Gardens		2	6	1	9	Mar. 1945
Heuningkrans	Wolmaranstad	J. J. Hoffman		8	27	11	46	Apr. 1945
						Total	61	

BLACK WILDEBEEST IN THE UNION GRAND TOTAL, APPROX. 1048

Farm	District	Owner	Number introduced	Number of Bulls	Cows	Calves	Total	Date of return
CAPE PROVINCE								
Benaauwdheidsfontein	Kimberley	De Beer's	2 Bulls & 2 Cows, 1920 from Newberry Estates	67	100	37	204	Feb. 1945
Mauritzfontein	Kimberley	De Beer's						
Groenvlei	Graaff-Reinet	J. P. Grobbelaar	About 1940	1	3	1	5	Mar. 1945
Groote Schuur	Cape Town	Union Government		1	3	2	6	Mar. 1945
						Total	215	
NATAL								
Tugela Drift	Klip River	J. Mattison	1 Bull & 3 Cows in 1918	3	11	3	17	July 1945

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THE ADULTERATION OF THE FAUNA AND FLORA OF OUR NATIONAL PARKS.

BY

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Read 4th July, 1946.

Whenever Europeans have settled in new countries, they have not only taken their domesticated animals and domesticated plants along with them, but have also shown a strong tendency to introduce wild animals from their homeland into the countries of adoption. In some cases, such as the Rabbit (*Oryctolagus cuniculus*) in Australia and New Zealand and the Musk-rat (*Ondatra zibethica*) in Central Europe, the results have been disastrous. The classic example of such a policy driven to excess is, no doubt, New Zealand, into which more than 600 species of mostly non-domesticated exotic animals have been introduced(8). Great losses are now being caused by some of the introduced kinds. Thomson's detailed study of the question in New Zealand still seems to be the only exhaustive treatise on the subject(8).

National parks are intended to preserve in perpetuity the fauna, the flora and all natural features of the areas concerned. It is not permissible, therefore, and must be deprecated from the scientific point of view, to introduce animals and plants into a national park, unless the species concerned were indigenous to the particular area at some time during its history. If this principle is not strictly adhered to, the term "national park" has no meaning.

Elsewhere(2) I have tried to give an account of some of the exotic species of animals introduced into South Africa. But since attempts are still made from time to time to adulterate the fauna of our national parks, it is desirable to discuss this question.

According to Stevenson-Hamilton(7), the Square-lipped or White Rhinoceros (*Ceratotherium simum*) disappeared from the Low Veld about the sixties of the nineteenth century and the Black Rhinoceros (*Diceros bicornis*) in the nineties. He expresses the opinion that their extinction was due to the activities of Joao Albassini's native hunters, who hunted for ivory and skins in the Low Veld.

In 1895, however, Kirby(4) came across a cow and a big calf of the Square-lipped Rhinoceros in the Matamiri bush along the south bank of the Sabi River. According to him this area was a favourite resort of *Ceratotherium simum* for many

years, though it was decidedly rare there in the year 1895 and altogether extinct by 1896.

Kirby also states that a few Black Rhinoceroses survived in the Lebombo and the Matamiri bush in 1896.

The Square-lipped Rhinoceros has never reappeared in the Kruger National Park, nor could this be expected, since the nearest specimens are found in Zululand at a distance of about 250 miles from the southern boundary of the Kruger Park.

Within recent years there have been sporadic reports of the presence of the Black Rhinoceros in the dense bush south of the Sabi River within the Kruger National Park. A summary of these occurrences is given in the annual report of the Warden of the Kruger National Park for the year 1936. In that report Col. Stevenson-Hamilton infers that a few Black Rhinoceroses are present in the Lower Sabi (Matamiri) bush during the summer months, and that they probably wander away into Portuguese East Africa when the waterholes have dried up. No Black Rhinoceroses or tracks have been seen in the Lower Sabi bush subsequent to the year 1938.

Since both the Black and the Square-lipped Rhinoceros formerly inhabited the Low Veld, there would be every justification from the zoological point of view to restock the Kruger National Park with both species. But apart from the difficulty of carrying out such a project, another aspect must be considered, and that is the reaction of the animals to tourist traffic. In the Zululand Reserves tourists are accompanied by game-guards, but this arrangement would hardly be possible in the Sabi bush of the Kruger Park, since a much greater and more densely bushed area is involved. Apart from the practical difficulties of transferring specimens from Zululand, the reintroduction of the Black and the White Rhinoceros into the Kruger National Park is a knotty problem. This question did engage the attention of the late Mr. Piet Grobler when he was Minister of Lands, but it never seems to have met with serious attention.

While, therefore, no objections can be made on scientific grounds against the reintroduction of the Black and the White Rhinoceros into the Kruger National Park, the position is not the same with regard to some other species.

Some years ago it was proposed to introduce the Springbuck (*Antidorcas marsupialis*) into the Pretorius Kop area of the Kruger Park. The Springbuck is a typical antelope of the interior plateau of the Union, and there is no evidence whatever to show that it ever occurred in the Low Veld of Eastern Transvaal. Hence there can be no justification for introducing it into the Kruger Park, where it has its counterpart in the form of the Impala (*Aepyceros melampus*). Fortunately the proposal was never carried out, but if it had been, nature would probably

have rectified this bit of human folly, since the specimens would, no doubt, have fallen an easy prey to the Park's carnivores.

Apart from Sclater's vague statement to the effect that "in Zululand there are also said to be some"(5), I have been unable to find any evidence to show that the Giraffe ever occurred in Zululand. Baldwin(1) went on a hunting expedition to St. Lucia Bay in 1852 and made three expeditions to Zululand in the years 1853, 1855 and 1856 respectively, but does not refer to the Giraffe in any of his accounts.

Giraffes are a never-failing source of attraction to tourists in the Kruger National Park, and this is, no doubt, the reason that prompted the proposal to introduce them into the Hluhluwe Reserve. But unless it can be shown that this species previously occurred in Zululand, its introduction will be a scientific anomaly.

Instances are not wanting in which exotic trees have been introduced into our national parks. This has been done, for example, at Pretorius Kop and apparently also at Hluhluwe in Zululand. As there are dozens of kinds of indigenous trees in the Kruger Park, at any rate, there should be no difficulty in selecting suitable species for the rest-camps. Exotic trees are entirely out of place in our national parks.

In order to prevent the overstocking of the small Bontbok National Park, the National Parks Board undertakes the capture of surplus Bontbokke (*Damaliscus pygargus*) at regular intervals, generally biennially, and distributes the specimens among interested farmers. If restocking is limited to areas in which the Bontbok formerly occurred, such action can be strongly commended from the zoological aspect. There is the additional advantage that new nuclei are being established, so that if an epidemic were to carry off the only national herd, the animal would not become extinct at one blow.

Throughout the world biologists are opposed to the adulteration of indigenous faunas and floras, but nowhere has the matter been more vigorously aired than in North America, where the following resolutions were adopted by the Council of the American Association for the Advancement of Science at the Toronto meeting held in December, 1921(6):—

> "*Whereas,* One of the primary duties of the National Park Service is to pass on to future generations for scientific study and education, natural areas on which the native flora and fauna may be found undisturbed by outside agencies; and
>
> *Whereas,* the planting of non-native trees, shrubs or other plants, the stocking of waters with non-native fish, or the liberating of game animals not native to the region, impairs or destroys the natural conditions and native wilderness of the parks;

Be it resolved, That the American Association for the Advancement of Science strongly opposes the *introduction of non-native plants and animals into the national parks* (italics by the present author) and all other unessential interferences with natural conditions, and urges the National Park Service to prohibit all such introduction and interferences."

In Britain the introduction of exotic species is also not favoured by scientists. In a report by the British Ecological Society in 1944(3) the following remarks are made in connection with the introduction of exotic animals at various times by the owners of estates: "The interest of some people in the new and bizarre is often stronger than in familiar native species, and the introducers probably gave no thought to the effects of the strangers on our native animals, or on other interests than their own, effects which are sometimes very serious. It is suggested that the introduction of exotic species should be forbidden except under special licence."

It is not, however, only the zoologists that are opposed to the adulteration of the denizens of our national parks. The same applies to the botanists in the case of the flora. In a recent study of the vegetation of the south-western Cape(9) Wicht writes as follows: "One of the greatest threats, if not the greatest, to which the Cape vegetation is exposed, is suppression through the spread of vigorous exotic plant species. These exotics are extremely difficult to control and possibly are already out of hand. It seems, at present, that unless enormous sums of money are expended on their eradication or control they will become dominant everywhere *except in nature reserves* and other selected areas *where they will be constantly destroyed.* (Italics by the present author). To botanists and all other lovers of nature the thought that such a change is likely to come is very distressing."

In order to protect the indigenous flora and fauna of Germany against adulteration, it is not permissible to liberate exotic plants or animals in that country without special permission from the state conservation department. Such matters are controlled by an ordinance for the protection of nature (Naturschutzverordnung vom 18 März 1936).

The question of the adulteration of the fauna and flora of our national parks is of the utmost importance, and although the introduction of exotic species is permissible under section 12 (3) of the National Parks Act, any such introduction would be a complete negation of the principal object of national parks. May one be permitted to express the hope, therefore, that the National Parks Board of Trustees will not only oppose any proposed introductions except in cases of restocking, but will

constantly be on its guard and will take steps to remedy the position where necessary.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 226-231, July, 1947.*

SOME FOSSIL HIPPOTRAGINE ANTELOPES FROM SOUTH AFRICA

BY

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With 2 Text Figures.

Read 3rd July, 1946.

INTRODUCTION.

Very few truly fossilised remains of Hippotragine antelopes have been recorded in South Africa and these have all been identified with the existing Sable (*Hippotragus niger*) and Roan Antelope (*H. equinus*). In 1940 Dr. Robert Broom showed to the writer a fossil antelope jaw which he had recovered from the cave breccia at Sterkfontein. This was clearly Hippotragine, but appeared to differ not only specifically but generically from the living forms. Dr. Broom generously offered this specimen to the writer for description along with a good deal of other material from the same group of caves. A preliminary account of the jaw was prepared but owing to the exigencies of war service it remained uncompleted and unpublished. At about the same time the Director of the South African Museum at Cape Town was kind enough to place at the writer's disposal some collections of fossil ungulates which had lain undescribed for many years. Amongst this material were two imperfect mandibular rami, apparently of a single individual resembling the Roan Antelope, which had been collected at Bloembosch in the Darling district. They are very well mineralised and on closer examination proved to be distinct from either of the living species of *Hippotragus*.

Recently an isolated Hippotragine tooth, collected several years ago at Sterkfontein, was shown to the writer by Dr. L. H. Wells. While this proves to belong to a living species it has been considered worthy of being reported alongside of Dr. Broom's specimen, as neither of the living species of *Hippotragus* has previously been recorded from any part of the Sterkfontein deposits.

THE BLOEMBOSCH SPECIMENS.

Hippotragus problematicus sp. nov.

Two incomplete mandibular rami (S.A. Museum No. 661 A), each with a complete set of cheek teeth in moderate wear, apparently belong to a single individual. They are quite well mineralised and in their state of preservation closely resemble

associated teeth of the extinct *Bubalus bainii* from the same locality. As will be seen from the illustration of the enamel pattern of the left series given in Figure 1 in comparison with the corresponding jaws of the living Roan and Sable antelopes, the agreement is so close that there can be no doubt of the generic reference of the fossil material. The fossil jaws appear to be closer to the Roan than to the Sable but there are a number of significant differences which warrant specific distinction.

In Figure 1 the three jaws have been aligned so that the boundary between the premolars and the molars in each jaw lie in a straight line. It is immediately apparent that in the fossil jaw the premolar series is proportionally longer than the molar series. The premolars of the Bloembosch specimen are closely similar both in size and in pattern to the premolars of the Roan while the molars are smaller and both in size and pattern lie in a position intermediate between the Roan and the Sable. Out of a number of specimens of *Hippotragus equinus* the specimen with the longest premolar series and the shortest molar series measured P_2—P_4 54.5 mm. M_1—M_3 78 mm. compared with 53 mm. and 71mm. respectively in the fossil form. An average Roan has the premolar series about 51 mm. long and the molar about 78 mm. In the Sable, average measurements are P_2—P_4 45 mm. and M_1—M_3 68 mm.

There appears to be adequate evidence for the specific separation of the Bloembosch fossils but unfortunately there already exists a distinct species *Hippotragus leucophaeus* (Pallas) (Blue-Buck) whose habitat was in the Cape Colony and which became extinct at the end of the eighteenth century but concerning whose teeth nothing is known. Sclater and Thomas (1900) state of this species: " Skull probably differing from that of *H. equinus* by its smaller size but, as far as is known, no museum possesses an example of it." The fossil jaws are a little smaller than those of the Roan and occur within the area once frequented by the Blue-Buck so that there is quite a good probability that they do represent that extinct species. However, since identity cannot possibly be established unless a complete skull is found (for the horns of the Blue-Buck are known from several frontlets) it seems unjustified to apply Pallas' name to the fossil material. In view of its problematical nature it is proposed to assign to the fossil jaw the specific name *problematicus*.

THE STERKFONTEIN SPECIMENS.

Hippotragus niger (Harris).

This species is apparently represented by a battered portion of a right mandible bearing an almost unworn third molar. The bone has been leached and later mineralised by calcite. The breccia from which it comes is imperfectly cemented and quite

unlike the main breccia of the upper quarry at Sterkfontein. In 1938 the writer described the geology of the Sterkfontein site and there mentioned the differences between the material from the upper quarry and from a lower cave. The present specimen comes from the lower cave and is presumably a good deal more recent than the specimen described below.

Hippotragoides broomi gen. et sp. nov.

A very fine series of left lower cheek teeth, together with broken mandibular bone, embedded in a dark brown matrix of fine material, which is mainly very well cemented, was recovered by Dr. Broom from the upper quarry at Sterkfontein. The jaw (Transvaal Museum No. 835) is shown in crown and inner lateral views in Figure 2. Comparison with the enamel pattern of the Roan Antelope illustrated in Figure 1 shows a very close similarity of structure. In the fossil jaw, however, there occurs in each of the three molar teeth a well developed internal basal pillar lying between the two main ribs and reaching the grinding surface in the first and second molars. Incipient internal basal pillars have been observed in occasional teeth in some jaws of *Hippotragus* but nothing of a comparable magnitude is known and this is regarded as a sufficient criterion for the generic separation of the Sterkfontein fossil, the name *Hippotragoides* being proposed to indicate its resemblance to the Roan and Sable. It may be remarked that another specimen is known and that this is not therefore a chance characteristic. A small internal basal pillar is noted by Pilgrim as a feature of the lower teeth of certain species of his Hippotragine genus *Sivatragus* from the Upper Siwaliks of India but the present material is quite distinct from it.

Apart from the well developed internal basal pillar, the premolar and molar teeth are closely similar to the corresponding teeth of the Roan Antelope. Comparative dimensions of specimens in comparable wear are:

	Sterkfontein Jaw.	*Average Roan.*
Length of Premolar Series ..	52.8 mm.	51 mm.
Length of Molar Series ..	77.4 mm.	78 mm.
Greatest length of M_3	22 mm.	25 mm.
Greatest length of M	18 mm.	17 mm.
Height ,of internal basal pillar		
in M_1	9 mm. (worn)	
in M_2	14.5 mm. (worn)	
in M_3	15 mm. (unworn)	

The molars of the fossil jaw seem slightly wider in proportion to their length than they are in the Roan, the internal basal pillars are somewhat better developed and the antero-external fold or flange is even stronger than in *Hippotragus equinus* but

all these minor differences are presumably subject to a range of individual variation such that they would probably be encountered in some specimens of the living species. The specific characters of the fossil teeth are thus very similar to those of the Roan Antelope apart from the generic distinction of the extra internal basal pillar in the molar teeth and there is also an internal column between the second and third lobes of the third molar not normally present in the Roan. It is proposed to designate this specimen *Hippotragoides broomi* in honour of Dr. Robert Broom, the discoverer.

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ABSTRACT.

A pair of fossilised mandibular rami from Bloembosch, in the Darling district of the South-Western Cape are described as a new species of Antelope, *Hippotragus problematicus,* which may possibly represent the extinct Blue-Buck, *H. leucophaeus* of which no skull or dentition is known. A tooth of the Sable Antelope is recorded from the breccia of the lower cave at Sterkfontein. From the upper quarry at Sterkfontein a well-fossilised lower jaw is described as a new genus and species *Hippotragoides broomi.*

EXPLANATION OF FIGURES.

FIGURE 1: Left lower cheek teeth of A: *Hippotragus niger* (Harris); B: *Hippotragus problematicus* sp. nov. and C: *Hippotragus equinus* (Desmarest). The three jaws are aligned with the boundary of the premolar and molar series in line. The different proportional lengths of the premolar and molar series of the fossil jaw will be clearly seen. Natural size.

FIGURE 2: Crown and internal views of type left lower jaw of *Hippotragoides broomi* gen et sp. nov. from the upper quarry at Sterkfontein. Natural size.

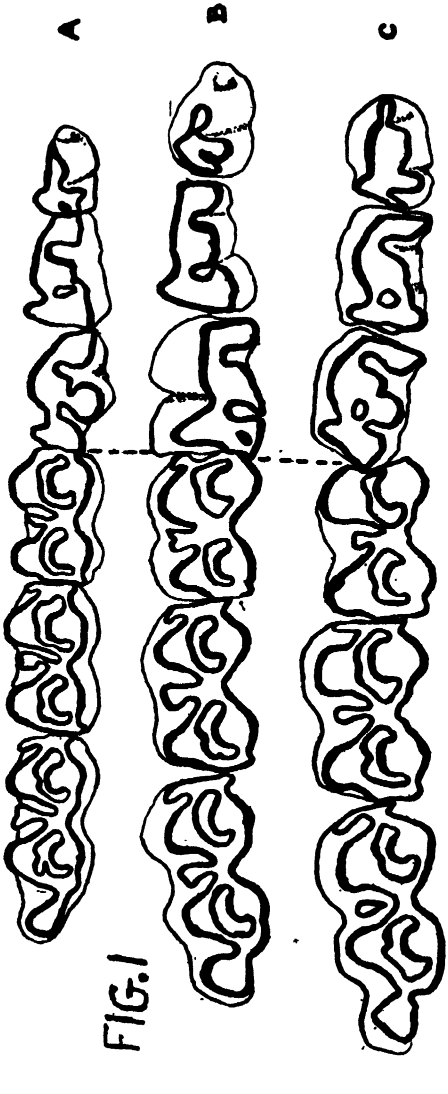

FIG. 1

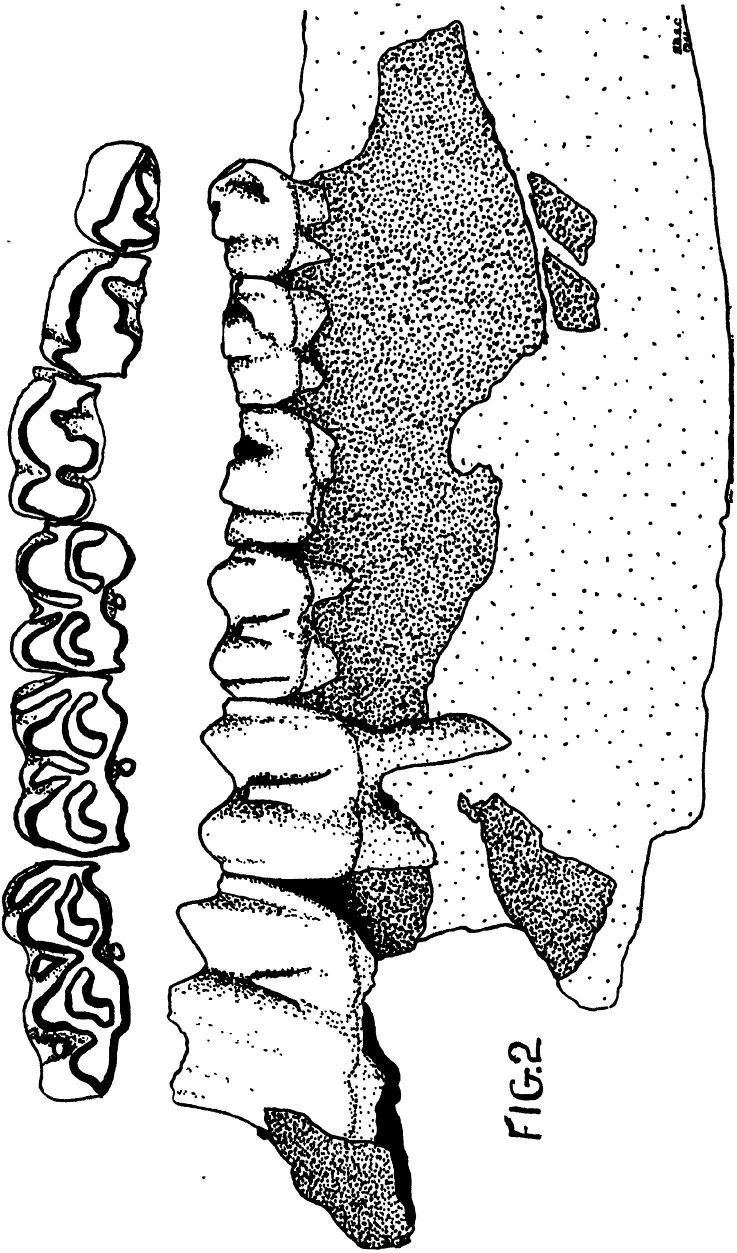

FIG. 2

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 232-235, July, 1947.*

FOSSIL MAMMALS FROM THE MAKAPAN VALLEY, POTGIETERSRUST, *III GIRAFFIDAE*.

BY

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With 1 Text Figure.

Read 3rd July, 1946.

The study of the numerous fossil ruminants from the Makapan Valley deposits has not been carried far enough to justify publication of the bulk of this material. However, the identification of a giraffe seemingly identical with the living species appears worthy of record for, as far as the writers are aware, this animal has not previously been reported in the fossil state in South Africa. At the same time, through the great courtesy of Dr. Robert Broom, the writers have been permitted to describe a valuable specimen from the Makapan Valley which had been in his possession for some time. This specimen clearly represents a gigantic giraffid, similar to the extinct Sivatheres of Asia and East Africa, and can plausibly be referred to a genus and species from the Vaal River gravels already described by Dr. S. H. Haughton.

Giraffa camelopardalis (Linnaeus).

Amongst material collected from the Valley lime works in December, 1945, is a lump of sandy limestone heavily veined with calcite and in this matrix lies a fragment of a left maxilla bearing two worn teeth. Careful cleaning shows that the highly mineralised fragment was embedded in its present imperfect state. The teeth, a left upper second and third molar, are typically giraffid in form and agree in size with corresponding teeth of the living South African giraffe. In pattern they also conform to molars of the living species though there is, in the fossil specimen, no direct evidence of the presence of the small internal basal pillar. However, the teeth are extremely worn and in its present state this small accessory column would be obscured or obliterated. In material from surviving species which we have been able to examine this column appears to fuse with the posterior lobe but in the fossil specimen it appears, if present, to have fused with the anterior lobe. It is very doubtful if this constitutes sufficient grounds for separating the fossil from the living species and it is most probable that it lies within the range of variation of the South African giraffe.

Griquatherium cingulatum Haughton.

This specimen came into Dr. Broom's hands from a lady whose name has, unfortunately, not been recorded so that it is

not possible to express our indebtedness to her as well as to Dr. Broom. The precise locality from which the specimen was derived is not known but it certainly came from the Makapan Valley and probably from one of the lime works.

The specimen comprises part of a very massive left mandible bearing the first and second lower molars in early wear and a fragment of an erupting fourth premolar exposed on the anterior broken surface. Part of the alveolus of the third molar is present but is filled with brown sandy limestone and calcite and there is no trace of the third molar tooth itself. Below the second molar the damaged jaw is over 80 mm. deep and was probably about 95 mm. in depth when complete. While the anterior break is fresh, the posterior break antedates the deposition and heavy mineralisation of the jaw.

It is immediately apparent that the jaw belongs to a very large giraffid. In dental characters as well as size it conforms to the extinct Sivatherine branch of this family.

The jaw and the teeth are illustrated in Figure 1. A break between the first and second molars exposes the posterior root of the first molar and permits the true crown height to be measured and the form of the tooth readily seen. The two molars have the following dimensions:

	LM_1	LM_2
Greatest length	49 mm.	53 mm.
Greatest breadth (at base)	34 mm.	34 mm.
Crown breadth	22-24 mm.	19-20 mm.
Greatest internal height ..	40 mm.	41 mm.
Greatest external height ..	38 mm.	40 mm.

The full crown height was probably about 50 mm. and not more than 55 mm. It will be seen that there is quite a marked lateral taper from the crown to the base, the profile being clearly indicated in Figure 1. Neither tooth has an accessory basal pillar. The enamel is somewhat rugose.

The general form and physical character of the teeth recall the upper molar described by Haughton (1922) from an unknown locality on the Vaal River. The upper tooth was moderately worn and had a crown 55 mm. long, nearly 55 mm. broad at its base and 34 mm. high with an estimated original height of about 50 mm. in the unworn state. From an examination of figures of upper and lower teeth of various members of the Sivatheriinae it would appear that the lower teeth are of the correct size and form to belong to Haughton's species though probably to a slightly smaller individual. The strong basal cingulum of the upper molar is lacking in the lower teeth, but this seems to be a variable character and is probably not significant. Since the lower dentition of *Griquatherium cingulatum* has not hitherto been recorded, this new fossil may be designated a neotype of that species.

Through the kindness of Dr. L. S. B. Leakey we have had the opportunity of examining casts of the upper and lower molars of the East African *Sivatherium olduvaiense*. Both the type upper molar of *Griquatherium cingulatum* and the referred lower teeth differ sufficiently from that species to justify referring them to a distinct form.

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ABSTRACT.

Amongst the fossil material collected from the lime works in the Makapan Valley in December, 1945, is a speciment containing two upper teeth of the living South African giraffe. This is believed to be the first record of this species in the fossil state. A specimen which came into the possession of Dr. Broom some time ago is recognised as the lower jaw of a large extinct giraffid of the Sivathere family and probably belongs to *Griquatherium cingulatum*, described by Haughton on an upper molar from the Vaal River.

EXPLANATION OF FIGURE 1.

Crown and inner lateral views of the two left lower molars referred to *Griquatherium cingulatum* Haughton. On the right is the posterior aspect of the first molar as seen on a broken surface of the jaw bone. Natural size.

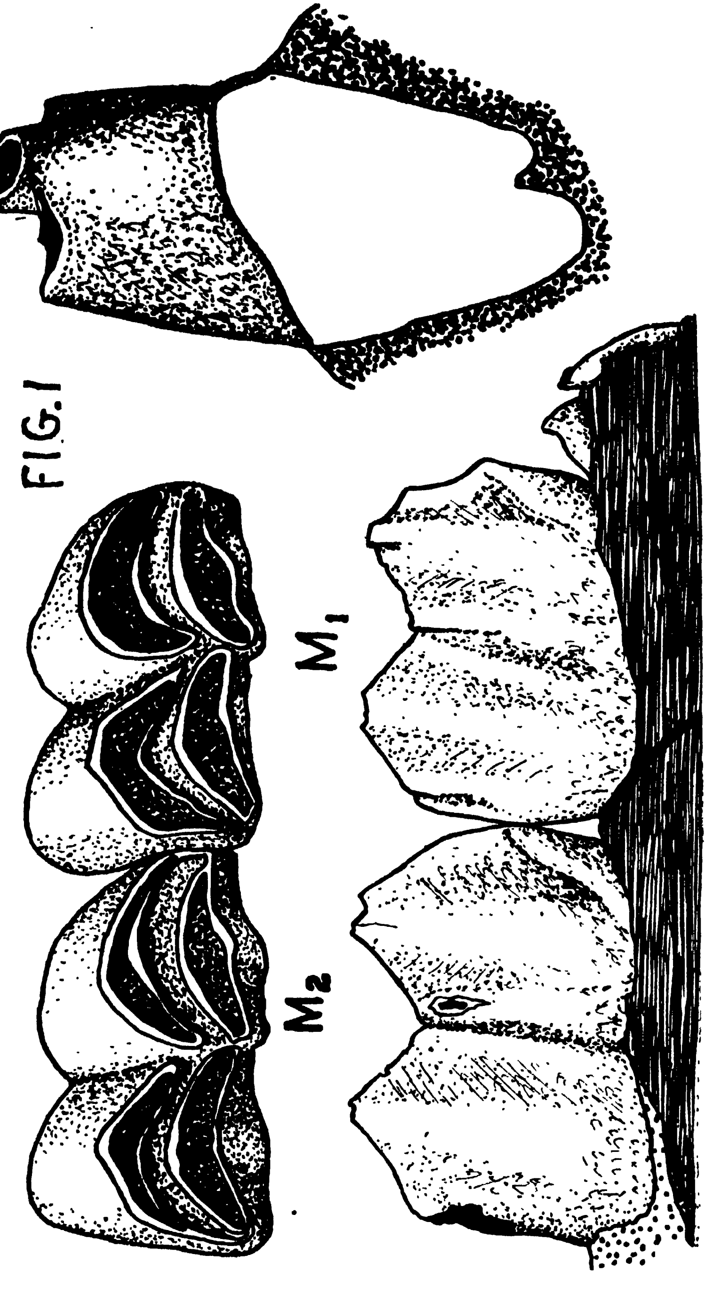

FIG. 1

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 236-239, July, 1947.*

A PRELIMINARY REPORT ON DIFFERENCE IN COLORATION OF ADIPOSE TISSUE IN THE BANTU

BY

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With 2 Tables.

Read 3rd July, 1946.

The subcutaneous adipose tissue of dissected female and male Bantu bodies is variously pigmented. The recent observations of Dam and Granados (1945) and Dam and Mason (1946) indicate that rats kept on a vitamin E deficient diet develop a brown coloration of adipose tissue in the midscapular region. This pigmentation of adipose tissue is attributed to the presence of highly unsaturated fatty acids of the diet, such as are contained in cod liver oil. This is said to be due to partial oxidation of the fat resulting in a brown discoloration.

In view of the high incidence of malnutrition amongst the Bantu it becomes necessary to set on record preliminary observations made on the colouring of the subcutaneous tissue of Bantu bodies dissected in the Anatomy Department.

MATERIAL AND METHODS.

This report embodies the findings from thirty Bantu bodies, six female and twenty-four male. Mappings were made of the different colours of fat on anatomical outline diagrams of the body. The colours fall mainly into two groups, namely, yellow and brown, appearing in varying shades of intensity in different regions. These colours were represented as B (brown), Y (yellow) and B/Y (a mixture of yellow and brown). The body was divided into 31 regions anteriorly and 35 regions posteriorly, the regions being numbered as in Tables I and II. It will be noted that both dorsum and palm of hand as well as dorsum and sole of foot are usually left out from the mapping as they had not been dissected at the time of the survey.

OBSERVATIONS.

In interpreting the results from the tables the following features become evident:

Posterior aspect:

The majority of bodies irrespective of sex show a deposition of brown fat over the scapular region extending over the neck and shoulders laterally and caudally over the thoracic and lumbar regions. A distinct circular area around the anus extending partly into the gluteal region on either side shows bright yellow fat. It is succeeded further laterally by brown fat. The brownish pigment continues over the thighs and upper arms whereas forearms and legs are covered by yellow fat.

Anterior aspect:

In spite of incomplete material, it is evident that the distribution of brown and yellow fat on the anterior aspect follows a pattern different from the above. Almost the entire anterior surface shows yellow fat in the majority of instances. Brown fat appears consistently across both shoulders while in 50 per cent. of the bodies the brown colour extends towards the midline to the level of the xiphisternum, whereas the other 50 per cent. show the yellow coloured fat.

COMMENT.

No attempt will be made here to discuss the significance of the difference in the coloration of the subcutaneous fat in the different regions of the body. This will only become possible when more extensive biochemical analyses are made of the characteristics of the coloured fat. The fact that pigmented fat can be produced by partial oxidation of some unsaturated fatty acids in Vitamin E deficient rats was of significance not only in respect of the variegated colour of the adipose tissue in the Bantu, but also in respect of similar intense pigmentation of the skin which had been noticed by Gillman and Gillman in the epidermis covering the pellagrous dermatitis. It remains for later investigations to discover whether the pigmented tissue is related to malnutrition. A comparison of the adipose tissue in Europeans and Bantus might materially assist in providing a solution to this problem.

POSTERIOR ASPECT.

No. of Region	Name of Region	No. of Recordings	Incidence of colour		
			Brown (B)	Yellow (Y)	B/Y
1	Cranial	29	25	3	1
2	Posterior cervical	28	22	6	–
3	Right shoulder	29	21	8	–
4	Left shoulder	29	23	6	–
5	Median posterior thoracic	29	19	6	4
6	Right lateral posterior thoracic	29	21	6	2
7	Left lateral posterior thoracic	29	24	4	1
8	Median lumbar	29	26	3	–
9	Right lateral lumbar	29	25	4	–
10	Left lateral lumbar	29	25	4	–
11	Anal	29	3	26	–
12	Left median gluteal	29	7	22	–
13	Left lateral gluteal	29	21	8	–
14	Right median gluteal	29	7	22	–
15	Right lateral gluteal	29	21	8	–
16	Left median posterior aspect of thigh	29	22	7	–
17	Left lateral posterior aspect of thigh	29	19	9	1
18	Right median posterior aspect of thigh	29	17	12	–
19	Right lateral posterior aspect of thigh	29	16	11	2
20	Left median posterior aspect of leg	29	9	17	3
21	Left lateral posterior aspect of leg	29	10	16	3
22	Right median posterior aspect of leg	29	6	19	4
23	Right lateral posterior aspect of leg	29	7	18	4
24	Sole of left foot				
25	Sole of right foot				
26	Left median posterior aspect of brachial	29	11	17	1
27	Left lateral posterior aspect of brachial	29	12	16	1
28	Right median posterior aspect of brachial	29	8	18	3
29	Right lateral posterior aspect of brachial	29	13	14	2
30	Left median posterior aspect of antebrachial	29	4	21	4
31	Left lateral posterior aspect of antebrachial	29	6	19	4
32	Right median posterior aspect of antebrachial	29	5	23	1
33	Right lateral posterior aspect of antebrachial	29	5	23	1
34	Palm of left hand	–			
35	Palm of right hand	–			

ANTERIOR ASPECT.

No. of Region	Name of Region	No. of Recordings	Incidence of colour		
			Brown (B)	Yellow (Y)	B/Y
1	Facial	1	1	2	
2	Anterior cervical	15	4	10	1
3	Left shoulder	24	13	8	3
4	Right shoulder	24	12	8	4
5	Median anterior thoracic	23	10	10	3
6	Left lateral anterior thoracic	26	8	13	5
7	Right lateral anterior thoracic	26	8	13	5
8	Median anterior abdominal	27	4	22	1
9	Left lateral anterior abdominal	24	7	15	2
10	Right lateral anterior abdominal	24	7	15	2
11	Pubic	27	8	18	1
12	Right median anterior aspect of thigh	21	3	16	2
13	Right lateral anterior aspect of thigh	21	3	16	2
14	Left median anterior aspect of thigh	19	4	11	4
15	Left lateral anterior aspect of thigh	19	3	13	3
16	Right median anterior aspect of leg	21	2	17	2
17	Right lateral anterior aspect of leg	20	2	16	2
18	Left median anterior aspect of leg	16	–	12	4
19	Left lateral anterior aspect of leg	16	–	12	4
20	Dorsum of right foot	–			
21	Dorsum of left foot	–			
22	Right median anterior brachial	24	7	12	5
23	Right lateral anterior brachial	24	8	11	5
24	Left median anterior brachial	23	7	13	3
25	Left lateral anterior brachial	24	9	12	3
26	Right median anterior antebrachial	18	3	13	2
27	Right lateral anterior antebrachial	20	4	13	3
28	Left median anterior antebrachial	20	4	13	3
29	Left lateral anterior antebrachial	20	3	14	3
30	Dorsum of right hand	–			
31	Dorsum of left hand	–			

ACKNOWLEDGEMENTS.

I wish to express my thanks to Professor R. A. Dart in whose department this survey was carried out and to Dr. J. Gillman at whose suggestion the work was initially undertaken. My thanks are also due to the students of the Science class, 1946, who helped to collect the data.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 240-251, July, 1947.*

PASTEURISATION OF MILK UNDER SOUTH AFRICAN CONDITIONS

BY

E. J. PULLINGER.

Read 3rd July, 1946.

INTRODUCTION.

The discussion now being opened originated from the question whether or not the South African Association for the Advancement of Science should, as an organisation, take sides in the controversy that is at present raging with regard to compulsory pasteurisation of milk. The whole question of pasteurisation has been thrashed out very thoroughly in the Northern Hemisphere and the arguments for and against can be read in standard text-books and especially in the book "Pasteurisation of Milk" by Prof. G. S. Wilson. What this Association therefore has to decide is whether the factors that have led to extensive pasteurisation overseas apply to South African conditions.

Broadly speaking the pros and cons of pasteurisation are as follows. Milk may serve as the vehicle for the spread of a number of diseases the important ones of which are tabulated below:

Diseases of man originating from unhealthy cows.

- Tuberculosis.
- Undulant fever. (Contagious abortion.)
- Salmonella Entero-toxaemia. (Bovine paratyphoid.)
- Staphylococcal entero-toxaemia. (Staphylococcal mastitis.)
- Scarlet fever. (Local udder infection.)
- Diptheria. (Local udder infection.)

Diseases of man originating from unhealthy milk handlers.

- Typhoid and paratyphoid fever.
- Salmonella entero-toxaemia.
- Staphylococcal entero-toxaemia.
- Bacillary dysentery (all types).
- Scarlet fever.
- Diphtheria.
- Poliomyelitis (not definitely proved).

In the Northern Hemisphere it has not proved practicable to eliminate from the average dairy herd all the cattle diseases listed in column No. 1, nor has it proved possible to ensure that at all times during production and marketing milk should be protected from possible contamination by human disease carriers. With the extensive pooling of milk supplies epidemics

became increasingly prevalent reaching a peak in the U.S.A. in 1914. Pasteurisation which was originally introduced to prolong the "keeping quality" of milk, proved to be an efficient and satisfactory way of controlling milk-borne diseases, so that with the extension of pasteurisation the incidence of milk-borne epidemics has been reduced very considerably. In a recent survey by Frank (1940) it is reported that out of 38 milk-borne epidemics that occurred in the U.S.A. during 1938 thirty-seven were due to the consumption of raw milk ; whilst the remaining epidemic arose from so-called pasteurised milk derived from a broken-down plant. This record not only demonstrates the value of pasteurisation, but also the need for adequate and constant supervision of pasteurising plants, if pasteurisation is to be a benefit and not a snare.

Opponents of pasteurisation overseas have based their campaign upon the following points:

That pasteurisation:—

1. Diminishes the nutritive value of milk and thus lays consumers of pasteurised milk open to disorders such as dental caries and avitaminosis.

2. Eliminates a natural "building up of immunity" against diseases such as tuberculosis which it is claimed occurs when raw milk is drunk.

3. Fails to destroy bacterial toxins which are heat-resistant.

4. Renders the milk unpalatable.

5. Engenders a sense of security that is ill-founded because pasteurisation is frequently inefficiently done, whilst milk may become recontaminated after pasteurisation.

The objections listed above fall into two categories, namely, those in which the danger of milk-borne diseases is subordinated to the nutritive importance of consuming only raw milk, or alternatively that milk-borne disease is an immediate and urgent danger against which pasteurisation offers only a very indifferent protection. Either class of argument is perfectly logical but all logic disappears when both arguments are used simultaneously. This leads to hopelessly confused thinking in the minds of many consumers who refuse pasteurised milk because the nutritive value has been destroyed, but buy raw milk and boil it to guard against enteric fever.

The answers to the objections listed above are:

1. The summation of all available experiments that have been properly controlled indicates that the nutritive

changes following pasteurisation are negligible and that there is no decrease in resistance to disease following the regular use of pasteurised milk.

2. The "immunity-building power" of raw milk is entirely hypothetical and all experience shows that the consumption of raw milk containing pathogenic bacteria will probably result in milk-borne epidemics.

3. Bacterial toxins are not destroyed by pasteurisation, nor are they destroyed by boiling in raw milk. If toxigenic bacteria gain access to milk an epidemic is likely to ensue, but pasteurisation will at least destroy the bacteria and so limit the toxin production.

4. and 5. These arguments fall away if pasteurisation is strictly controlled, and strict control is imperative.

6. For satisfactory pasteurisation, strict prepasteurisation grading of milk is imperative. The eradication of bovine disease is not primarily a public health problem but an agricultural one upon which all dairy economics depend.

Pasteurisation was introduced in the first instance to make it easier to market "long distance" milk in big cities, and this commercial trend towards pasteurisation has been encouraged by public health authorities on account of the obvious advantage of a process which eliminates most of the infections likely to be spread by milk. Pasteurisation, which is a heating process, considerably reduces the general bacterial flora, thus improving the keeping quality of the milk. At the same time all pathogenic bacterial contaminants are destroyed with the exception of spore-bearers such as Anthrax bacilli and *Clostridium welchii* and certain bacterial toxins such as those of the salmonella genus and of certain staphylococci.

Under South African conditions the question of improving the marketability of milk is becoming one of increasing importance because with the rapid growth of our large towns, with more intensive settlement of the peri-urban areas and with rapidly growing costs of milk production near built-up areas, the zones of milk production (for the fluid market) are spreading further and further afield. To-day Cape Town draws milk from as far as Bonnievale and Oudtshoorn; Durban draws from the Natal Midlands, Eston and Ixopo; Pretoria draws from Standerton and even from White River; whilst the Witwatersrand milk comes from a semi-circle bounded by Lichtenburg, Klerksdorp, Basutoland, Wakkerstroom, Ermelo and Witbank. Clearly therefore any procedure likely to enhance the marketability of our milk supplies has much to commend it from the economic viewpoint. Turning to the public health aspect it is necessary to review very briefly the dangers that may attend the consumption

of raw milk, and for greater detail in this connection reference may be made to Prof. Wilson's book.

DANGERS OF RAW MILK.

Bacteria pathogenic to man are liable to be found in milk coming from cows infected with:

(*a*) Tubercular mastitis causing tuberculosis particularly in children.

(*b*) Contagious Abortion causing Undulant fever in man.

(*c*) Bovine paratyphoid fever if it occurs in a urinary, intestinal or septicaemic form may gain access to the milk in which case it will give rise to an epidemic of gastro-enteritis.

(*d*) Diphtheria as a local teat infection causing diphtheria in man.

(*e*) Streptococcal mastitis due to *Strep. pyogenes* causing scarlet fever and septic sore throat in man.

(*f*) Certain forms of staphylococcal mastitis may cause gastroenteritis in man.

In South Africa the bovine type tuberculosis is not commonly encountered in man although infection occurs in many of our dairy herds. The disease does, however, always exist as a possible public health danger. Moreover there is little if any hope of eradicating this disease from our dairy herds during the next 25 years. Undulant fever attacks man more often than is generally admitted and again the control of contagious abortion in our dairy herds will not be accomplished for many years to come. The same remarks apply to salmonella food-poisoning in man and bovine paratyphoid fever. So long as man can act as a carrier of diphtheria bacilli and scarlet fever streptococci there will always be a danger of cows developing teat or udder infections from such carriers. Also there is no practical way of controlling staphylococcal mastitis. It must be accepted therefore that it will be many years before any assurance can be given that milk is safe as it comes from the cows.

Milk may also be contaminated after withdrawal from the cow either directly by milk handlers or indirectly by flies or polluted water. Diseases commonly spread in this way are:

(*a*) Enteric or typhoid fever.

(*b*) Paratyphoid fever.

(*c*) Salmonella food-poisoning.

(*d*) Staphylococcal food poisoning.

(*e*) Bacillary Dysentery of all types.

(*f*) Diphtheria.

(*g*) Scarlet fever.

In addition there are diseases such as poliomyelitis about which there is some doubt.

To prevent raw milk becoming contaminated by flies or by dirty water should be easy theoretically, though in practice it can be very difficult particularly in the case of flies. To prevent the possibility of direct contamination of milk during milking by human carriers of disease is virtually impossible.

With regard to typhoid and paratyphoid fever, carriers may be identified by the Vi test in a high proportion of cases but circumstances can arise which render the application of this test impractical or too costly in proportion to the results likely to be achieved. Such conditions apply with regard to the Witwatersrand where the milk supply comes from about a thousand dairy farms scattered over sixty thousand square miles of territory. Any Vi testing that can be done can only be of a token nature and it is virtually impractical to give an assurance that only Vi negative persons handle milk on South African dairy farms. Consequently, speaking for South Africa as a whole, it is necessary to introduce some safeguard other than Vi testing if typhoid epidemics are to be avoided. In any case it is quite as important to exclude other diseases which have been mentioned and this would involve a further series of regular swab, stool and urine tests for a host of pathogenic bacteria. In one American investigation upon the practicability of such regular testing it was found that the identification of each carrier cost in the region of £200. Furthermore taking the case of scarlet fever type streptococci, about 24 per cent. of all dairy workers were found to be carriers at one time or another during a three month survey, the carrier state usually being associated with a sore throat. Obviously if a quarter of the dairy personnel are to be thrown off work periodically because they are transient carriers of potentially dangerous streptococci an impossible situation arises where every farm has to carry surplus fully tested workers to the extent of 25 per cent. merely to replace the streptococcal carriers temporarily withdrawn from duty. If all the other possible diseases were brought into the survey an utterly impossible situation would arise.

One is forced therefore to the general conclusion that it is Utopian to consider the possibility of a general raw milk supply which has been produced under conditions guaranteed free from all danger of contamination by bovine or by human carriers of disease germs and it becomes necessary to look for other means of avoiding milk-borne epidemics.

At this point it is appropriate to stress that as a town grows or as the population of a country increases, milk-borne epidemics become an increasing menace. When the population is small most consumers buy their milk from a local producer and if an epidemic occurs it is confined to a single small milk round. With

the growth of a town it becomes an economic necessity to develop large milk pooling and distributing depots because locally situated producers can no longer provide the gallonage required. With the growth of pooling depots an epidemic is no longer confined to a small milk round and one diseased cow may contaminate tens of thousands of pints of milk and so spread disease to hundreds or even thousands of households.

Safeguarding Milk Supplies.

The methods at present available for rendering milk safe are:

(*a*) Boiling.

(*b*) Pasteurisation.

Of these boiling is the more reliable because it involves a greater degree of heating, but the process has certain disadvantages. Firstly, it must be done by the actual consumer and very often the consumer will neglect this precaution. Moreover it is extremely difficult to boil and re-cool (a very necessary portion of the procedure) milk where it is being used in large bulk by schools or hotels. Another disadvantage is that it is rendered less palatable by boiling whilst a certain amount of the nutritious quality is destroyed. The only measure that remains is that of pasteurisation.

Definition of Pasteurisation.

In the modern sense pasteurisation is described by any one of the three following definitions, and it rests with the local legislators in any area to decide which of these definitions is acceptable.

(*a*) The heating of every drop of milk to 142.5 to 145° F. and holding it all at that temperature for at least 30 minutes. This is known as "holder" pasteurisation.

(*b*) The heating of every drop of milk to a temperature of 161.5° F. and maintaining it at that temperature for 14 to 15 seconds.

(*c*) The heating of every drop of milk to a temperature of 161.5 to 162.0° F. and maintaining it at that temperature until all phosphatase enzyme is destroyed. Definitions (*b*) and (*c*) are variations of the short-time-high-temperature or S.T.H.T. method.

Each definition should be concluded by the requirement that after pasteurisation the milk should immediately be cooled to about 40° F. The difference between definitions (*b*) and (*c*) lies in the omission of the time factor of the latter. This is done because it is impossible during actual pasteurisation to measure the rate of flow accurately at any given moment. The flow can be checked before and after but not during the run and so the

rate of flow cannot be subjected to an actual check by the controlling authority. The final criterion of satisfactory pasteurisation is the destruction by heat of phosphatase enzyme and many legislators prefer to include this criterion in the definition rather than a time criterion that cannot be checked at any instant.

Effect of Proper Pasteurisation.

It has been amply proved that the degree of heat mentioned in these definitions destroy all the usual pathogens found in milk with the few exceptions that have already been mentioned, such as spore-bearers and bacterial toxins. The evidence in this connection is too voluminous to be quoted here but it is fully reviewed by Prof. Wilson. The degree of heat applied when milk is properly pasteurised is such that the taste is practically unaltered. As regards nutritive changes, these are of a negligible degree except in regard to Vitamin C which is very largely destroyed by the heat. Actually Vitamin C in milk is very unstable and even in raw milk is rapidly destroyed when subjected to daylight, so that there is no great difference between the vitamin C content of pasteurised milk and raw milk which has been subjected to the normal distribution handling which is unavoidable in a large city.

The summation of all comparative experiments that have been done on the relative feeding value of raw and pasteurised milk indicates that these two products are of equal value.

Once again it is quite impossible to review the evidence here but a critical survey may be found in Prof. Wilson's book. In this connection it is necessary to issue a warning against judging or rather misjudging the feeding value of pasteurised milk upon a basis of some single badly planned and ill-controlled experiment. Probably the most significant experiments in this connection are those done with calves because cows milk is the natural food of the calf and any damage done to the milk by pasteurisation would surely be reflected in the growth curve. Actually no significant difference has been found in the growth of calves fed with raw or pasteurised milk. With regard to children no truly balanced observations have yet been made, but such observations as are available have shown no difference in the feed value as a result of pasteurisation.

Significance of Pasteurisation in the Provision of Safe and Clean Milk.

Reasons have already been presented to show that from both the public health and economic viewpoints the extension of pasteurisation is desirable, but it must be appreciated that this process is no more than one link in the "safe and clean milk" chain, and to concentrate upon wholesale pasteurisation to the exclusion of all other measures, would result in catastrophe.

The very first aspect of the dairy industry that has to be tackled is:

HEALTHY HERDS AND SOUND ANIMAL HUSBANDRY.

This is the key, and the only key, to a thriving dairy industry. All possible steps must be taken to build up healthy herds throughout the country, not from public health reasons but because the economic stability of the dairy farmer ultimately depends upon his having a healthy herd of reasonably high producing cows which give milk well above the legal minimum standard. A reasonable target at which to aim for the time being is that all dairy cows should average 3 gallons a day for a 300 day lactation period and that their milk throughout the year should contain at least 3.5 per cent. butter fat and 8.5 per cent. non-fatty solids. It must be appreciated that this target is far beyond the reach of the average dairy farmer engaged in the fluid milk trade, whilst with regard to the factory trade (butter and cheese) too little attention is given to the economics of production, and the tendency is to have very low gallonage cows which are expected to live off the veld. Excluding the extent to which low productivity hinges upon the relatively low price of factory milk, the other factors involved, particularly upon fluid milk farms, are:

(*a*) The prevalence of chronic streptococcal mastitis in dairy cows. This disease reduces the output of the udder and worse still seriously reduces the protein content of the milk.

(*b*) The prevalence of such diseases as contagious abortion, metritis and contagious vaginitis which cause losses in milk, interfere with calving cycles, and ultimately may render cows barren.

(*c*) The prevalence of debilitating diseases such as tuberculosis, mange and tick infestation (the latter not really a disease), which lower the stamina and productivity of cows.

(*d*) Erratic feeding methods ranging from actual semi-starvation to plentiful feeding upon hopelessly ill-balanced rations.

(*e*) Faulty breeding methods whereby too much stress has been laid upon gallonage to the exclusion of chemical composition of the milk. Alternatively, where chemical content has been considered, attention has been confined to butter fat records whilst non-fatty solids records have been ignored.

All these factors combine to undermine the efficiency of the dairy industry and an inefficient dairy industry in turn must undermine agriculture as a whole since so much of our general agriculture should hinge ultimately upon the demand for and

market value of stock feed. A pasteurisation scheme should be supported by a disease eradication scheme for improving the quality of dairy herds.

Hygienic Dairying Methods.

Hygienic dairying is of vital importance to the industry not merely for public health reasons but because unhygienic methods result in a product lacking in keeping quality, and subject to heavy spoilage losses which throw a big and quite unnecessary strain upon the economic structure of the industry. It might be urged that economic loss is the just punishment of the individual whose dairying methods are open to reproach. Unfortunately, the losses due to the failure of the individual inevitably spread over the whole industry. In the first place a share of the meagre supply of stock feed has been used to produce an easily spoiled product, and a number of the limited supply of dairy cows have been misused in that way. Meanwhile this easily spoiled product makes its presence felt throughout all subsequent handling and processing, because first grade cheese and butter cannot be manufactured from third class raw material. Nor is it correct that any filthy old milk can be pasteurised. It should be clearly understood that the final pasteurised product will only be satisfactory in regard to taste, smell, nutritive and keeping quality if the raw milk subjected to pasteurisation is itself of a satisfactory standard. In other words any scheme for the extension of pasteurisation must be preceded by a scheme for the grading of all milk prior to pasteurisation. This question of the pre-pasteurisation quality of milk is of paramount importance.

In this connection it is necessary to issue a warning against the fallacy of attempting to use pasteurisation as an instrument for furthering animal disease eradication schemes. For instance, if a scheme were afoot for eradicating bovine tuberculosis, it would be a mistake to try and salvage the milk from tuberculosis herds by insisting that it be pasteurised. Such a move should be opposed, not through any fear that pasteurisation might fail to render the milk safe, but because of the adverse propaganda that would arise if milk known to contain tubercle bacilli were diverted to the ordinary pasteurising depots. Such milk would, of course, have to be salvaged, but the salvage should be done either at specially supervised butter and cheese factories where processing was under strict supervision of the controlling authority, or alternatively at pasteurising depots under special control issuing "low-grade" cheap milk for cooking purposes only.

Efficient Pasteurisation.

Throughout this address use has been made of the terms "efficient", "satisfactory" and "proper" pasteurisation. This is because experience in South Africa has shown that many

operators consider that it is sufficient to pass milk through a warming machine for it be labelled pasteurised. In a recent survey covering 13 plants in 8 different towns efficiency of heat treatment varied very considerably. Whilst some firms showed less than 0.5 per cent. of samples to be under-pasteurised, most showed at least 5.0 per cent. to be insufficiently heated, whilst in some cases the figure for underheated samples varied from 10 to 50 per cent. In other words one firm pasteurised no more than half its milk properly. Gross or extensive under-pasteurisation is unforgivable because of the false sense of security which is engendered. Over-pasteurisation on the other hand, though in no way dangerous, may render the milk unpalatable and reduce its nutritive quality.

It is obvious therefore that for proper pasteurisation, only certain approved apparatus should be used, and numerous safeguards with regard to the proper use of this apparatus must be introduced. Moreover the whole process must be properly supervised by the controlling authority through the joint use of daily visual inspection coupled with the daily collection of a wide range of samples covering the whole output of the factory. These samples should invariably be subjected to the phosphatase test.

Prevention of Recontamination.

Clearly all efforts to obtain a safe milk supply will be wasted if properly pasteurised milk is allowed to be subjected to recontamination by pathogenic bacteria. Where such recontamination is liable to occur, tremendous disasters may be anticipated. The classical example of this occurred in Montreal in 1927 when 5,000 cases of typhoid fever developed as a result of the consumption of supposedly pasteurised milk. On investigation it was found that much of the milk was never pasteurised, whilst the presence of a typhoid carrier in the pasteurising depot coupled with bad dairy hygiene suggested that post-pasteurisation contamination may also easily have occurred. A less spectacular but more definite example was that of the Baltimore Scarlet Fever epidemic when properly pasteurised milk became contaminated with scarlet fever streptococci as a result of excessive exposure in 5-gallon cans, jugs and glasses.

Until pasteurised milk has been placed in properly washed and sterilised bottles and until these bottles have been sealed and overcapped, all handling should be entirely automatic and the cleansing and sterilisation of all milk tanks, pipe-lines and automatic filling and capping machines should be maintained at the highest possible level by a controlling laboratory. This would involve the taking of daily tests from the entire circuit for keeping quality and general plant hygiene.

Under no circumstances is it safe to decant pasteurised milk into 10 gallon cans for transhipment, and even pasteurised milk in sealed bottles should never be transhipped long distances except under refrigeration conditions.

The question of Vi testing and swab-testing of milk handlers has already been discussed but it must not be thought that the conclusions arrived at in connection with farm milk handlers apply also to depot milk handlers. In the case of milk depots and particularly pasteurising plants no obstacle should be allowed to interfere with routine Vi testing of all milk handlers, whilst there are grounds for urging that bacteriological testing for all forms of dysentery should be introduced.

It is necessary, however, to emphasise once again that the bacteriological testing and clinical examination of milk handlers is incidental to the real problem of avoiding recontamination. However exhaustive the testing may be, milk handlers may easily be infected with say septic sore throat, diphtheria, one of the dysenteries or even typhoid fever just after the routine test has been performed, and such an individual will be in contact with the milk when it is most susceptible to infection. The ultimate answer to the whole matter lies in automatic handling of pasteurised milk until it is sealed in bottles, automatic and thoroughly efficient washing and sterilizing processes, coupled with hour by hour and day by day bacteriological control of such depots to forestall those breakdowns that will inevitably occur from time to time.

Review of the Position.

Summarising what has been said in the last section, a clean and safe milk supply involves:

(*a*) Improvement in animal husbandry and animal health.

(*b*) Improved dairy hygiene and transportation of milk.

(*c*) Strict grading of incoming farm milk preferably with the payment of a higher price for a better product.

(*d*) Pasteurisation under strict control.

(*e*) The laboratory control of all pasteurisation and post-pasteurisation handling.

(*f*) The establishment of laboratories adequate to deal with the grading of raw milk as well as with the pasteurisation and post-pasteurisation control.

CONCLUSION.

In conclusion it may be said that an attempt has been made to present the case for pasteurisation in the short time available. It remains for the Association to decide the following points in the order they are set out:

1. Is it desirable to pasteurise any more milk than is already being so treated.
2. If so:
   (*a*) Should all milk be pasteurised; or
   (*b*) Should certain classes of milk be exempt.
3. If certain classes of milk are to be exempt how are they to be defined.
4. If extensive pasteurisation is advocated is it to be:
   (*a*) Pasteurised alone; or
   (*b*) Pasteurised coupled with the other improvements and safeguards that have been outlined.

It must, of course, be appreciated that if pasteurisation is deemed desirable it must be applied to manufactured products like butter and cheese as well as to fluid milk and also to sweet and sour cream used for luxury trades.

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THE COMPARATIVE REACTION OF MERINO SHEEP FOLLOWING CONTINUED EXPOSURE TO SUNLIGHT AND SHADE

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In a previous communication (*This Journal*, Vol. 41, 1945) attention was directed to an experiment in which white rats were exposed under identical conditions to the climatic environment of eight widely separated localities in South Africa for a period of eighteen months. From this investigation strong evidence was afforded that these animals were capable not only of continued existence in all the localities, but that in five out of the eight centres there was a very close grouping of body weight curves throughout the whole period. This indicated that climatic conditions in themselves were definitely not inimical to the existence of this mammal in any of the centres selected.

From observations already made in the field, merino sheep avoid strong sunlight as far as possible by seeking whatever shelter is available especially during warm weather. Consequently stock owners are frequently advised to provide tree shelters in their stock paddocks against adverse weather conditions. In order to evaluate the relative significance of sunlight and shade on merino sheep, an experiment was started at Onderstepoort on six groups of ten weaner lambs to each group. The experiment was duplicated so as to include equal numbers of males and females segregated from each other.

1. In the two groups referred to as "*optional*" the animals were allowed to move at will between sunlight and shade.
2. In the two "*sunlight*" groups, all the animals were continuously exposed to full sunlight except on rainy days when they were kept under shelter.
3. The two "*shade*" groups were confined throughout under a low-roofed thatched shelter with open sides. This allowed for a full play of all the meteorological influences on them except for *direct solar radiation* which was completely excluded at all times of the day.

Both in the "sunlight" and "shade" groups, exercise was strictly limited as each group was confined to a wire-netted paddock of 10 feet square provided with a concrete floor. In the "optional" group more exercise was allowed between their "shade" and "sunlight" paddocks.

In order to exclude the effect of intercurrent conditions, all animals were treated for internal parasites and the faeces examined for worm eggs at regular intervals. Furthermore the diet was accurately controlled and kept on a comparative basis. At first this consisted of lucerne hay and crushed yellow maize and subsequently of poor quality veld hay only. Thus far the experiment has been in progress for a period of 3½ years and may be concluded within the next six months.

Experimental Results Achieved.

The experiment was conducted so as to provide data of various types. All these findings will be analysed statistically and correlated as far as possible on completion of the work. The following brief account merely serves to indicate the nature of the data collected and the general trends which the investigation has so far followed.

1. *Meteorological Observations.*—A meteorological station was erected in the immediate vicinity of the experimental animals and full meteorological readings taken daily including total solar radiation under the direction of Miss G. Riemerschmid. In all bioclimatological investigations hitherto conducted, great difficulties have been experienced in correlating the various meteorological findings with the reactions shown by living systems and in this work also, further attempts are being made to overcome this thorny problem.

2. *Diet and Food Consumption.*—All animals were kept on the good diet from January, 1943, until April, 1945, when the rams were changed over to poor quality veld hay only. Follow-the death through malnutrition of half the number of rams during the winter months of 1945, the remaining rams were given a supplementary ration of lucerne and maize from October, 1945, onwards, when the ewes in turn were placed on the poor diet for the summer season of 1945-1946. Food and water intake for the different groups were determined at monthly intervals stretching over periods of six days each. In view of the wide fluctuations encountered in the data on consumption, further statistical examination is required before these can be interpreted.

3. *Growth and Body Weight.*—Body weights were recorded regularly at weekly intervals following the removal of food and water overnight. Body measurements on the other hand were taken once per month. Despite variations in food and water consumption, one of the most significant features in the whole experiment was the persistently close correlation in the body weights between the respective "sun" and "shade" groups. The "optional" groups on the other hand showed consistently higher weight curves than the others. Conspicuous differences were likewise evident between the two sexes. While the various

groups were kept on an adequate diet, all the animals were in robust health. With the change in diet, however, a progressive loss in condition was evident in all the groups.

4. *Other Physiological Responses.*—No significant differences could be detected in the heart rate and rectal temperature when the sexes were compared in their own respective groups. During warm weather the rectal temperature of ewes was, however, inclined to be slightly higher than that of the rams. With regard to respiration, striking differences could be recorded especially during the warm summer months when respiration rates of 300 per minute were frequently noted in the "sun" groups as against 20-40 in the "shade" groups. This accelerated shallow breathing which is in the nature of a panting reflex is initiated primarily through heat stimulation of the skin. Thus it is promptly elicited in freshly shorn sheep when placed in the sun in contrast to long woolled animals in which there is a considerably longer time lag. Despite the open mouth frequently associated with this panting in sheep, it is, however, not accompanied by an increased flow of saliva and the characteristic dribbling as seen in dogs, cattle and white rats. Moreover no signs of active sweating could be detected anywhere on the skin by means of the starch-iodine test even during periods of extremely warm weather and associated with violent panting. The only exception was a very slight indication of moisture on the skin of the scrotum and inguinal region of a few individual animals. After the experiment had been in progress for two years and the respective groups thoroughly adapted to their environmental conditions, the "shade" groups were exposed in full sunlight for a whole day during mid summer and their reactions compared with those of the sun adapted groups. An analysis of these data proved that all animals in the "sun" groups showed lower respiratory rates and rectal temperatures than did the shade adapted groups. Moreover the reactions of the "shade" ewes to sunlight was less marked than those noted in the "shade" rams.

Apart from the effects of sunlight on individual physiological responses, it was found that the feeding of lucerne itself produced a transitory though definite rise in heart rate, respiration, and rectal temperature in all the groups.

From a comparative series of determinations made by Miss Riemerschmid on skin temperature, rectal temperature and respiration on these sheep, evidence was adduced of wide differences between the skin capillary responses not only on different parts of the animal body but also between the "sun" and the "shade" groups especially during cold weather.

5. *Sexual Function.*—While all the groups were on a good diet no differences whatsoever could be detected in their sexual activity. This applied to the oestrous cycle of the ewes, which

was tested for twice daily as well as the sperm picture of the rams which was examined at intervals by Dr. Starke. When the rams were changed over to the poor diet, however, this was followed by a progressive atrophy of their testes and subsequently by a definite deterioration of the semen in all the groups. By returning the rams to a better diet, a rapid improvement in the semen picture followed even before the general condition and body weights had improved significantly. This observation affords evidence of the response of the genitalia of severely undernourished animals even to a very slight improvement in the diet from an extremely low starvation level, and before any increase in body weight could be detected. The oestrous cycle of the ewes remained unaltered for a period of two months despite the poor diet and loss of condition. This subsequently resulted in an-oestrus in practically all the ewes. When they were finally returned to the good diet of lucerne and maize, apparently normal oestrous responses were initiated within a few weeks.

6. *Blood Picture*.—This was studied at regular intervals on samples drawn from each animal. No differences could be detected between comparable groups as far as red cell precipitate, haemoglobin, total white cell count, differential white cell count, blood sugar, non-protein nitrogen, and total lipoids, were concerned. On changing over to the poor diet, definite decreases could, however, be recorded in the red cell precipitate, haemoglobin, and total white cell content of all the animals. Again, however, no group differences could be detected by Dr. Clark, and Messrs. Bekker and Malan who undertook the various blood determinations.

7. *Wool Studies*.—All the experimental animals were shorn twice annually in March and in September and their clean wool yields recorded. In addition wool samples were taken at regular intervals and the following determinations made by members of the Wool Section, viz.: fibre thickness, total number of fibres per square inch and their progressive increase, staple lengths, crimping, grease and suint content. From all these data, no significant differences could be found in the wool from comparable groups. On the poor diet, however, both the yield of wool was decreased and the physical characteristics of the fibres weakened, as was to be expected from previous experience.

8. *Pathological Findings*.—Except for the death of one ram from a urethral calculus while on a good diet, all the other deaths followed after the animals had been kept on the poor hay diet. In the rams death was invariably associated with extreme cachexia, general atrophy, anaemia, and diffuse oedema. While a similar picture was noted in a few of the ewes which died, the majority of them succumbed very suddenly as a result of ketosis ("domsiekte"). In all such cases good amounts of

fat, although partly necrosed, were still present in their bodies. These deaths are indicative of characteristic sex differences in sheep when they are suddenly changed from an adequate to a starvation diet.

SUMMARY.

Farmers are frequently advised to provide shelter for their stock against adverse weather conditions. In order to ascertain how merino sheep would react if continuously exposed in direct sunlight in contrast to others completely sheltered from sunlight, a long term experiment was conducted at Onderstepoort stretching over a period of three and a half years. Selected sheep were kept under strictly controlled conditions throughout, and all precautions taken against intercurrent diseases and possible differences in their diet. While the "shade" groups were permanently confined under a low-roofed thatched shelter, the "sun" groups were kept in full sunlight from morning till evening each day.

From the various data recorded throughout the whole period, no significant differences could be detected between these groups, both in rams and in ewes, as far as the following items were concerned.

1. Growth and body weight.

2. Pulse and rectal temperature.

3. Sexual function.

4. Blood picture.

5. Wool (including both yield and physical characteristics).

Seeing that no differences could be found while the animals were on a good diet for a period of two years, they were subsequently swung round on to an extremely poor diet. This resulted in progressive loss of condition to such an extent that nearly half the animals died from poverty. Again, however, no significant differences could be detected between the "sun" and "shade" groups, although with the change in diet very marked decreases could be recorded in body weight, sexual function, red and white blood cells, and wool yields in all the groups. Of the other physiological responses studied, the only characteristic feature was the high rate of respiration in the "sun" groups which ranged up to 300 per minute during warm weather as against 20-40 per minute for the shade groups. This accelerated breathing in sheep, as in dogs, is purely of a reflex nature and must be regarded as a normal physiological adaptation in the control of body temperature especially in view of the fact that no sign of sweating could be detected anywhere on the skin of these

sheep. Although all these results were obtained under carefully controlled experimental conditions, it cannot be concluded from this that the same would apply under the divergent farming conditions in South Africa. Seeing, however, that from a climatic environmental aspect very wide differences were created as between continued exposure to sunlight and complete sheltering against it, clear evidence was afforded that at least as far as heat and active radiation from the sunlight was concerned, the merino sheep offers a remarkably wide range of physiological adaptation. From experiences so far gained in regard to bioclimatological investigations on sheep and rats, there is strong evidence to indicate that climatic differences, at least within South Africa itself, are of less significance as primary factors to the welfare of man and his domestic animals than of the *plant life from which their food is derived* as well as of such *lower animal orders as insects, arthropods and helminths frequently encountered as parasites and vectors of disease.* It is on these grounds, therefore, that bioclimatological research work in South Africa should be directed far more extensively and intensively to our economically important plants and animal parasites than has been the case hitherto.

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BIOCLIMATOLOGICAL STUDIES ON WHITE RATS IN SOUTH AFRICA. SKIN CANCER FOLLOWING CONTINUED EXPOSURE TO SUNLIGHT

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In order to ascertain the relative effects of sunlight and shade on white rats of the Wistar strain, three comparable groups of young weaner males were drafted into an experiment which was started at Onderstepoort in October, 1941. Each group was comprised of 10 animals which were kept in two standard size wire cages with five rats to each cage. Body weight which at the outset varied between 40 and 50 grams per animal was recorded regularly at weekly intervals. All animals were fed on a standard, well balanced dry ration; both the feeding and the watering being so arranged as to allow for accurate weekly determination of the intake by the various groups. While the ration of one-half of the animals in each group was carefully restricted so as to allow for minimal growth only (A1, B1 and C1) the remaining half of each group was allowed an unrestricted amount of the same food (A_2, B_2 and C_2). All rats in the A series were regularly exposed to direct sunlight on clear days for a period of 4½ hours starting at sunrise. The reason for limiting exposure to 4½ hours daily was due to the fact that previous short term experiments had shown that where rats were exposed to full sunlight after midday, sudden deaths from heat stroke were encountered especially on hot summer days. After that they were placed under hessian shelters, open at the sides, so as to allow for full sky radiation on to the animals during the rest of the day. At night and during rainy weather all the groups were kept in a closed shed. In the B series all animals were similarly exposed to sunlight for 2½ hours daily before being removed to the hessian shelters, while animals in the C series were continuously sheltered in a stable away from doors and windows in an area provided with subdued, diffuse daylight only, i.e. completely out of reach of any direct sunlight.

While the above experiment was started at the onset of summer in 1941, a second one identical in nature was initiated

during the autumn of 1942. Throughout the experimental period, attention was directed mainly to the growth curves of the various groups during the different seasons, their food and water consumption, and their physiological responses to the different forms of treatment. Whilst these data are to be presented in a separate publication, this report briefly summarizes the findings concerning the characteristic skin lesions which developed in 13 out of 22 rats exposed to sunlight for 4½ hours daily and in 1 out of 22 rats exposed for 2½ hours each day.

Incidence and Nature of Skin Lesions.

The first evidence of the development of any skin lesions began to appear after the animals had been exposed for a period of 10 months. On the ears this took the form of a slight localised thickening and roughening of the epidermis usually noticeable on the upper surface of one ear at first and subsequently also on the other. With progressive keratinization, a hard white nodule was thus formed which in turn changed to one or more horny outgrowths on the ear. It was only after this stage had been reached that an increased active vascularization round the base of the new growth became visible, and this resulted in the rapid development of a neoplasm embracing the whole of the external ear and the surrounding facial area. Associated with increased vascularization, ulceration and traumatic injury caused in the cage, haemorrhage on to the surface was frequently noticed. Unless such animals were removed from the cages in time, they were attacked by the others and the tumour devoured thus causing the death of the affected animals. Where this was forestalled, death usually followed after progressive body wastage and repeated haemorrhage from the tumour, now prominently developed on the head.

Where the eyes were involved, the first change noticeable was in the form of a pin-point like reddening on the brim of either the upper or lower eyelids. Subsequently this became transformed into a focal hyperkeratosis and a horny outgrowth. With progressive involvement of the whole area surrounding that eye, further development of the tumour was similar to that described above. Although the eyes and ears were most commonly affected, three of the rats developed similar tumours which started on the point of the nose, while in two the toes of the front feet were involved in tumour growths. In no case, however, were lesions noticed on the hind feet probably as a result of their sheltered position under the body, or on the tails which although hairless and continuously exposed, were sufficiently protected against active radiation by excessive keratinization normally present and by the soiled state of the tail.

Of the total number of rats exposed for 4½ hours daily, 6 out of 11 on a restricted diet developed skin tumours while 8 out of 11 on a full ration were likewise affected. Although both groups were definitely susceptible, there was some evidence to suggest that tumour development was slower in the groups kept on a restricted diet than amongst the others. That these tumours were caused by solar radiation was proved by the fact that there was no evidence whatsoever of any new growth amongst the groups continuously sheltered in the stable and in only one rat from those exposed for 2½ hours daily. The specific role of ultra violet rays in causing skin tumours experimentally is suggested from the work of Findlay (1929), Putschar and Holtz (1930), Wahlgren (1932) and others who exposed mice to ultra violet radiation.

Microscopic Character of the Tumours.

Although macroscopically these tumours appeared to be of a malignant character, there was no evidence at autopsy that metastatic foci had been formed anywhere in the body.

The tumour itself on section usually appeared greyish white and of a marrowlike consistency. Microscopically the earliest changes were in the nature of epithelial "pearls", concentrically laminated with epidermoid cells on the outside and keratinized cells on the inside, associated with signs of hyperkeratosis in some cases. In some sections the cells showed marked anaplasia and varied from spindle shaped to polyhedral forms especially in the depth of the tumour. Giant cells with giant nuclei were not uncommonly seen in such sections, the nuclei themselves being variable in size, shape and number.

According to Roffo (1935) who observed similar neoplasms in rats exposed to sunlight, these lesions varied from those of a spindle cell sarcoma to those of a true carcinoma in different localities of the body.

From the above account of our own findings there is strong evidence to indicate that these tumours developed by rats after exposure to sunlight are in the nature of *spindle cell-like epidermoid carcinomata*.

There was no indication, however, of any form of sarcoma as described by Roffo although in some places the cells and their arrangement resemble such tumours.

Whether these sun cancers as described in rats bear any relationship to skin cancer in the human being remains an unsettled question in view of the massive doses of sunlight required to produce them, whereas in the case of human beings such consistent and prolonged exposure very seldom applies in practice.

NOTE.—A fully detailed report of this paper will be published in the *Onderstepoort Journal of Veterinary Science.*

RAT WITH TUMOUR ON EAR.

South African Journal of Science, *Vol. XLIII, pp. 262-265, July, 1947.*

THE PROBLEMS PRESENTED BY THE CONTROL OF TSETSE FLIES IN THE UNION OF SOUTH AFRICA

BY

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Read 4th July, 1946.

Although constituting one of the major problems, if not the greatest problem, of tropical Africa by virtue of the fatal disease trypanosomiasis of man and animals transmitted by them, tsetse flies are confined in the Union to a comparatively small tract of country some 130 miles in length in Zululand on the east coast.

Within that area three species only occur, the forest and riverine thicket species, *Glossina brevipalpis*, the savannah species, *G. pallidipes;* and the savannah thicket species *G. austeni.*

Early reports such as are contained in the writings of the pioneer Louis Trichardt indicate the presence of tsetse flies, most probably *G. morsitans,* along the Limpopo river and its tributaries about 1838. This species disappeared at about the time of the Rinderpest epidemic in 1896 and has not recurred since.

Tsetse flies depend for their food supply solely upon the blood of mammals and in a few cases that of birds and reptiles, and the various species are limited so far as their distribution is concerned by climatic factors principal amongst which are shade and humidity and possibly to a lesser degree temperature. Thus *G. brevipalpis* is confined to the thickets bordering rivers and in deep valleys as this species cannot exist in the absence of a dense overhead canopy and a high degree of humidity. *G. pallidipes* again favours savannah interspersed with more heavily bushed watercourses to which it can retreat during unfavourable seasons or even during the hotter portions of the day. *G. austeni* appears to be met with only in low dense thicket where shade appears to be the main requirement and humidity of less importance.

The climatic requirements of the various species are reflected also in their periods of activity, as is evidenced by the presence of *G. brevipalpis* only in the early hours of the morning and late afternoons extending even until after dark, particularly on moonlit nights. *G. pallidipes,* on the other hand, is active for a much longer period during the sunlit hours remaining active frequently all day during still warm overcast weather.

The range of activity is also dependent upon the climatic predilections of the different species and, whereas *G. brevipalpis*

is limited to the forest-clad valleys of the Hluhluwe Game Reserve and the riverine thickets of the lower Pongola River, *G. pallidipes* occurs over a wide area in Zululand including the Umfolozi, Hluhluwe and Mkuzi reserves together with certain areas which we are inclined to regard as extension areas from these habitual foci. *G. austeni*, in so far as we know the habits of this species, is confined only to certain localised areas of very dense thicket near the Mkuzi River.

The life histories of the various species are all very similar, the females depositing a single active larva at intervals of approximately 14 to 18 days on ground rich in humus under the overhanging canopy of bushes and shrubs. The larva immediately penetrates the soil to a depth of not more than 1 inch and within an hour forms a characteristic brown or black pupa. These pupae hatch normally within a period of approximately 30 days but hatching may be delayed for a period of up to two months depending upon climatic conditions. In her life or from 4 to 6 months the female may deposit up to 12 larvae.

As will be readily appreciated from a consideration of the above facts the problems presented by the control or eradication of tsetse flies are extremely complex and difficult. Various possibilities present themselves which may be grouped under the following headings:

1. Upsetting the climatic requirements of the flies. The objects aimed at are
   (*a*) preventing the flies from obtaining the degree of shade and humidity which they require both for their existence and for the deposition of larvae, by discriminative clearing of certain types of bush within their permanent haunts;
   (*b*) limiting the dispersion of fly by the creation of barriers in the form of strips in which all bush has been removed over an area wide enough to prevent flies from crossing them. Such barriers are best created along the edges of the normal permanent haunts of the fly.
2. Removal of the source of food of the fly and incidentally, the sources from which the flies acquire their infection. This may be achieved by the elimination of game and has been applied very successfully in the case of *G. morsitans* in Southern Rhodesia. *G. pallidipes*, due to its habit of feeding on small game species such as a warthog, bushpig, bushbuck, etc., in addition to the larger species, is not so easily controlled by this method as nothing short of total extermination of all game species appears to be successful.
3. Biological control. There are various species of hymenopterous parasites and one known species of the

Bombyliidae which parasitize the pupae. Predaceous flies such as asilids and Bembex wasps may be encouraged but all appear to offer little more than only very partial control.

4. Erection of places designed to attract the females to deposit their larvae which may be destroyed from time to time. This method has been used against *G. palpalis* in East Africa with little success.
5. Trapping. Traps such as the Harris Tsetse Fly Trap have been thoroughly tested over many years in Zululand but it seems doubtful whether any measure of success can be expected from their use.
6. Direct attack upon the adults by the use of insecticides which may be applied in the form of solutions either as space sprays where the object is to destroy the adults present at the time of application, or applied to foliage, etc., where the residual effect will operate on adults subsequently alighting upon the treated surfaces. Application may be undertaken by spraying such solutions from atomisers on the ground or aircraft may be employed which are capable of covering large areas in a short time.

   Recently investigational work into the application of D.D.T. and Gammexane in aerosal or smoke form has been undertaken. Two methods of producing such aerosols are being investigated

   (*a*) by means of chemical smoke candles or generators; and

   (*b*) by using the hot exhaust gases from aircraft engines to vaporize the insecticides.

In the light of our present knowledge it seems doubtful whether any one method alone will succeed in controlling tsetse flies. Bush clearing, which is an extremely expensive and laborious undertaking whether total or discriminative, has for its chief objects the limitation of the numbers and spreading of the flies but, nevertheless, forms an essential part of any campaign. Elimination of the source of food of the fly although theoretically capable of exterminating the species bristles with practical difficulties and here it must be pointed out that no game extermination is being undertaken in the Hluhluwe Game Reserve and that the White Rhinoceros is being retained in Umfolozi, with the result that two foci in which tsetse fly can persist are being retained. Trapping has proved over many years of intensive investigation to offer little more than a useful index of the presence and relative abundance of the flies whereas biological control and attacks upon the pupal stages, although not very intensively studied in the Union, appear to offer little hope of control.

The use of the newer chemical insecticides in conjunction with bush clearing and game control for the direct attack upon the adult fly appears to offer more hope of success. Here it must be pointed out that only the adult stage can be reached, and taking into consideration the life history of the fly, it will be necessary to apply the insecticides at intervals designed to prevent adult females from depositing larvae, and over a period of sufficient duration to ensure the destruction of all flies emerging from pupae present in the ground at the commencement of application.

In conclusion it must be pointed out that although in relation to the rest of the Union the country at present infested by tsetse flies is comparatively small in extent it represents some of our most valuable cattle country. The presence of tsetse flies, by virtue of the disease Nagana or trypanosomiasis transmitted by them, makes the farming of livestock in the area at best a most hazardous undertaking and at the worst impossible. The permanent occupation of land by a pest of this nature presents a challenge to us which appears to justify its eradication by all the means at our disposal and the reclamation of an extremely valuable tract of country for agricultural and pastoral pursuits as well as the preservation of an interesting and almost unique fauna.

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THE ROLE OF THE DEVELOPING EGG IN VIRUS RESEARCH

BY

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Read 3rd July, 1946.

During the last few years a large number of papers have appeared in the literature on the uses to which the developing hen's egg have been put in work on virus diseases. Apparently some of these have caught the imagination of the public because several well-written articles have appeared in the lay press. The subject of this paper is, therefore, at least topical, but, to make it all the more appropriate, I have paid particular attention to the fact that it is being presented to the Association for the Advancement of Science—with particular emphasis upon the advancement of science. It is not my intention to deal with the viruses which have been cultivated in eggs, to describe the vaccines which have been prepared from such cultures, or to outline the contributions that have been made to our knowledge of immunity, by adaptation of the technique to particular problems. Rather do I wish to direct attention to a few of the very prominent mile-stones along the road of progress in bacteriology and to indicate that the virologist, although he is travelling along an almost parallel road, apparently either refuses to, or is unable to profit by earlier experiences.

I do not think that I am in any danger of contradiction if I say that probably no branch of biology has made more progress in the last decade than the study of virus diseases. I purposely confine myself to biology because undoubtedly the art or science of wanton destruction has reached a pinnacle of perfection which was not envisaged even five years ago. To give but a very few examples to illustrate the point—Yellow Fever is no longer a dreaded scourge, thanks largely to the efficient vaccine which was developed by that brilliant band of workers at the Rockefeller Foundation. Typhus, which, as shown by Zinsser in that delightful book " Rats, Lice and History ", has played a leading part in international affairs for centuries has been relegated to an almost insignificant role, and it seems that influenza, one of the greatest industrial and economic scourges of our day, is about to be brought under control. All this progress has been condensed into a period of about 15 years and is comparable to the extraordinary progress which was made in the study of infection and infectious diseases at the end of the last and the beginning of the present century. The real development of bacteriology as a subject of scientific study dates from the middle of the 19th century and is the

direct outcome of the work of Louis Pasteur. Probably the birth of the study of viruses and virus diseases was the demonstration by Loeffler and Frosch in 1898 that foot and mouth disease was caused by an agent, which could pass through an unglazed porcelain filter that could retain the smallest known bacterium, and which was below the limits of microscopic visibility. Let us now consider the analogy in the progress that has been made in the study of these two closely related branches of scientific study that were commenced at different times.

When Pasteur was busy with his epoch-making study of fermentation he was well aware of the two differing schools of thought with regard to the genesis of living organisms. He noticed that not only the number of species but the size of living entities that were supposed to be capable of spontaneous generation were diminishing rapidly (remember that in the 16th century, Van Helmont actually offered a prescription for making mice), and he, Pasteur, devised and carried out a number of experiments which caused him to throw in his lot with those who believed that all existing living cells arise from pre-existing cells. This was probably the birth of bacteriology, and although Pasteur introduced into the study the conception of virulence and attenuation of bacteria by serial passage in fluid media, no great progress was made until 1891 when Robert Koch announced his technique for the propagation of bacteria on solid media. This was followed by the adaptation of the method to the propagation of an almost endless number of different bacteria, until at the beginning of the present century a bacteriologist was regarded as something of a novice or an amateur if he had not devised a particular nutrient medium which was peculiarly adapted to a particular organism. At this stage progress in the study of infectious diseases and their control made remarkable strides and this branch of science passed definitely into the hands of the bacteriologists. Unfortunately, the giants amongst the bacteriologists of the day were bacteriologists in name only. Possibly of necessity, they were more interested in what bacteria do than what they are, more interested in how they interfere with, or could be harnessed to aid, our every day economy than in the way they live and function as autonomous living beings. Admittedly great contributions have been made to the purely scientific as opposed to the applied aspect of the subject but there remain so many omissions that even to-day our knowledge of bacteriology as a whole is a patchwork. To give an example:—the synthesization of the sulphonamides and their application to the control of bacterial infections very rightly has been hailed as one of the greatest of recent achievements. Initially the mode of action of the drugs was not known but subsequently it was shown, and repeatedly confirmed, that their action is due

to the removal of the chemically closely related but essential para-aminobenzoic acid from the environment. Had the essential role of this growth promoting factor been appreciated earlier, and did we have an exact and comprehensive knowledge of the complete nutritional and environmental requirements of even a few bacteria, is it not reasonable to assume that the control of the pathogenic bacteria would be even further simplified? Moreover would the production of bactericidal substances in addition to penicillin and streptomycin not be allowed to proceed rapidly and smoothly on a rational basis instead of by the laborious hit or miss method of to-day. Now let us pass over to a consideration of what is going on in the world of viruses to-day.

It was Pasteur with his work on rabies who showed that an infective agent which could not be cultivated by ordinary bacteriological means could be studied by animal passage. This technique was used for almost half a century and progress was made but it was painfully slow. As recently as 1938 a section of the British Association at its centenary meeting devoted a whole morning to a discussion as to whether it was permissible to classify a virus as a living entity, and at times the discussion, to which some of the leading biologists of the day made valuable contributions, veered dangerously close to a dissertation on spontaneous genesis. As a result of later work one by one the original concepts of a virus have been discarded. It is futile to say that a virus is an infectious agent which will pass through a filter capable of retaining the smallest bacteria. Elford developed his *gradacol* membranes which may be prepared at will of a porosity to pass or keep back even the smallest virus particle. It is ridiculous to say that a virus is below the limits of visibility. Electron microscopy, which is still in its infancy has brought them all within those limits. One only of the original criteria is valid to-day—a virus will multiply only in the presence of living cells. History again repeated itself and showed that progress in science is dependent upon progress in and development of technique. Maitland and Maitland developed a technique of virus cultivation which is merely an adaptation of the technique to which the mystic name tissue culture is usually applied. It consists merely of adding finely minced tissue to a suitable isotonic nutrient fluid with full aseptic precautions so that the cells of the tissue either multiply slowly or do not die. When virus was added slow but unmistakable multiplication followed. Various modifications were adopted, even including adaptation to the use of solid media, but the virus titres were invariably low and the method, though of great interest, has proved as yet to be of little value. Then came the development and extension of Goodpasture's original work on the use of the hen's egg with its developing embryo. Now we have what is to-day regarded as the ideal medium in which to cultivate

viruses. Eggs are comparatively cheap and normally are obtainable in large numbers. With ordinary care, each mass of living cells may be delivered to the laboratory in its own container in a bacterially sterile condition, i.e. each egg is the direct analogue of the autoclaved tube of media of the bacteriologist. It merely remained to simplify Goodpasture's original laborious method of inoculation so that large numbers of suitably incubated fertile eggs could be seeded expeditiously with any given virus emulsion by any ordinary technician. Very soon a number of ingenious but simple modifications were brought into general practise so that to-day the inoculation of an egg by Cox's method of injection directly into the yolk sac or by Burnet's method of infecting the clorio-allantoic membrane is if anything simpler than seeding a tube of broth. Immediately a number of workers applied themselves to the new technique and we had the rush of reports on the cultivation of this or that virus in the developing chick embryo. (I was even a culprit myself.) Since the control of the disease and not the study of the virus *per se* was the aim and object of almost every investigator, we soon had the development of a number of highly efficient vaccines. The analogy with the bacteriologists of the beginning of the century in preparing special media for special purposes was carried a step further when Gear, for instance, showed that fertile ducks eggs are more suitable for growing a certain rickettsia than fowls eggs. As a continuation it is not unlikely that the near future will bring to light a number of publications on the superiority of, say, plovers eggs or budgerigar eggs for particular purposes in view of the fact that no less a technician than Dr. Honor B. Fell has shown that budgerigar eggs are more suitable than hen's eggs for the study of certain embryological developmental phenomena. This is apart entirely from the knowledge that from the point of view of different viruses each hen's egg may be regarded as being akin to the curate's egg—good in parts—the clorio-allantoic membrane is most suited to the propagation of the viruses of the pox group, the embryo itself is of greatest value to a large number of others while the extra embryonic fluids are of greatest interest to the workers with influenza viruses. The point I wish to make is the use of the developing fertile egg is only in its infancy. It has been shown that yellow fever virus, horsesickness virus, bluetongue virus, to name but a few, may be attenuated by serial passage—merely a further application of Pasteur's original conception. It has been shown that the most suitable conditions for the multiplication of bluetongue virus are provided by an embryo which had been incubated for eight days at 37.5° C., then infected with 1,000 minimal infective doses of virus, incubated for 24 hours at 35° C. and then transferred to 32° C. for 48 hours. Further that for each 1.5° C. increase in the temperture of incubation above 33.5° C. the ultimate virus titre of the

culture decreases tenfold. But in no case do we know why, and the best we can do is to say that the observations are very interesting and of immediate practical importance. All this in spite of the fact that bluetongue is a disease of sheep and that the maximum titre of virus is found in the blood of a sheep at the height of the reaction which frequently reaches 42° C. It is abundantly clear, therefore, that apart from some success in the control of disease all that we are doing is to collect a heterogeneous mass of facts and empirical data and are treading the same path as our predecessors, the bacteriologists who have bequeathed to us a patchwork of knowledge of the bacteria. Is it not time that we decide to profit by experience and call a halt? Economic considerations are of importance but to the true scientist the acquisition of exact knowledge is of greater importance, and must result in the paying of bigger dividends in the form of increased benefits to man, animals, and plants. Admittedly quite a lot of work has been done on the pure science aspect of viruses. The size of a very large number has been acurately determined by filtration and centrifugation, the density, molcular weight, isolectric point, diffusion constant and shape have been calculated and quite a lot is known of the physical properties. But of certain fundamental characteristics we know nothing. Consider yellow fever and horsesickness viruses. Although they differ quite a lot in size they have many characteristics in common. Both may be changed to a neurotropic form and attenuated by serial passage through the brains of mice, both may be propagated in and attenuated by passage through fertile eggs, both may be cultivated quite easily in Maitland medium, yet horsesickness virus is characterised by great viability remaining active in citrated blood at ordinary temperatures for years, while yellow fever virus is fragile and dies out completely in a few days. And we have not the remotest idea why. The use of the developing egg has provided a technique with potentialities which appear to be limitless. Cannot someone sponsor an effort which will bring the virologists the bacteriologist, the chemist, the physicist, together to profit by the mistakes of the past, to study the viruses as living entities, to gather together exact knowledge of their environmental requisites and to bring about an abandonment of the present experimental empiricism which obviously borders on quackery. I think this Association for the Advancement of Science could and should take a lead.

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RICKETTSIA CANIS INFECTION IN DOGS IN THE PRETORIA DISTRICT

BY

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INTRODUCTION.

In 1938 the disease caused by *Rickettsia canis* (Donatien and Lestoquard, 1935) was recorded for the first time in the Union of South Africa by Neitz and Thomas. Simultaneously a report also appeared by Lawrence of morbidity in Southern Rhodesia due to the same cause. In the case of the Union outbreak mysterious deaths on a large scale among domestic and wild dogs in the Kruger National Park had been reported by the Warden and game rangers, and it was these deaths which were investigated by Neitz and Thomas. They were able to transmit the disease by subinoculation into healthy dogs and subsequently showed that *Rickettsia canis* was mainly responsible for the deaths.

In the years that followed, nothing further was heard in the Union of this disease, outside the Kruger National Park. At the beginning of April of this year, however, a dog here which had previously shown a very light infection with a particularly mild experimental strain of *Babesia canis* and had been clinically normal for some time subsequently, was found dead. It showed signs of anaemia and slight icterus. Blood smears were negative for *B. canis* and the aetiological diagnosis remained obscure until organ smears were found to reveal the characteristic inclusions of *R. canis* in the free monocytes. A special lookout was kept for outside cases amongst dogs presented for examination from the surrounding district, and within a few days the first cases were diagnosed. Within a month some twelve of them had been found suffering from the disease. In a few of these there was an intercurrent infection of *B. canis*.

HISTORY AND DISTRIBUTION.

It is of interest that this malady was described for the first time, and named, only three years before the publication of Neitz and Thomas, by Donatien and Lestoquard of the Pasteur Institute in Algeria who immediately started research work on it and in a series of articles up to 1940 contributed much of the valuable knowledge of the disease. In the course of this work it was found also to occur naturally on the Mediterranean coast of France. It is still considered by Sergent (1945) in his annual report of that Institute to rank with Leishmaniosis as

the cause of the most frequent and serious dog morbidity in Algeria. Babesiasis holds a minor position.

Danks in 1937 recorded the occurrence of the disease in and around Nairobi and gave a description of its clinical forms and some experimental data.

In 1939 Pigoury and Bernard found the disease on the eastern Mediterranean littoral. In the same year Carmichael described a number of cases which were diagnosed in Uganda, together with his clinical and haematological findings.

West Africa came into the picture in the same year, Malbrant describing a disease in which was found a parasite morphologically identical with *R. canis.* He, however, expressed some scepticism as to whether this was the same organism as the North African one, since he was able to infect guinea pigs and even rabbits, while monkeys were refractory, findings which were contrary to those of workers elsewhere.

Gillain (1942) diagnosed the disease in the Belgian Congo but found it to be a fairly mild one except in mixed infections with *B. canis,* as did Mudaliar (1944) in South India, where apparently persistent fever and anaemia were the only notable symptoms.

Diagnosis.

The reason for all these almost simultaneous discoveries in the different countries of an apparently enzootic and widespread disease, and the reasonable assumption that it is considerably more widely distributed, is apparently due to the fact that the disease shows no definitely pathognomonic or characteristic clinical features. In addition, the diagnosis is difficult and not likely to be arrived at, unless suspicion of its presence leads one to make a definite search for the parasites.

It is stated in the literature that diagnosis is, in general, easy from organ smears (notably lung, liver, and bone marrow) collected at biopsy or autopsy, but that it is difficult and frequently a fairly laborious procedure if smears from the peripheral blood are utilised. We have tried the various biopsies but soon found blood smears, if made from the ear with particular care as to the preparation, to possess decided practical advantages for routine diagnosis, and even to a large extent for experimental purposes. The essential here was to find a method which would so concentrate the leucocytes on the smear that there would be the minimum of labour in seeing as many as possible of the monocytes in the shortest time. With this end in view, we found the following points in the preparation of the smear to be important:

1. That the glass slides should be clean;
2. that only a small amount of the first drop of blood to emerge should be used;

3. that the " push " method of making a smear is preferable to the " pull " method as the white cells of the blood tend to " follow " the edge of the upper slide, and so move to the extremity of the smear. Very few of the rather fragile monocytes are damaged;
4. that the upper slide should be pulled away from the lower one when it has travelled about ½"-1", by which time the blood should be just about exhausted.

A little practice is needed to make good smears in which the majority of monocytes are grouped along the two edges and the somewhat serrated " tongue ". The fact that, during a large part of the course of the disease, there is a decided and striking monocytosis, considerably facilitates diagnosis. In our hands we have found these smears to possess decided advantages over the organ smears, mainly due to their clarity and the absence of the " dust cells " and other large macrophages of the lungs, of the liver cells in liver smears, and of the large immatures of the haemopoietic series in the bone marrow and spleen.

The differential diagnosis has been fully discussed by Neitz and Thomas (1938) and need not be repeated here.

AETIOLOGY.

The disease is caused by a parasite known as *Rickettsia canis,* which is recognised by its characteristic inclusions in the monocytes of the blood. These inclusions have been exhaustively described by Donatien and Lestoquard, and other workers. These two authors (1938, 1940) have described what they consider to be the life cycle of the Rickettsia in the cytoplasm of the monocyte. Using the terminology of Halberstaedter and Prowazek, they describe the break-up of the rather dark reddish homogeneous " initial bodies " into colonies consisting of small granules, the " elementary bodies " which tend to stain lilac with Giemsa. This stain has generally been the most suitable for studying the morphology of these organisms.

These colonies of " elementary bodies " then separate or disintegrate into individual " elementary bodies ", which in their turn invade new monocytes and become " initial bodies " which grow, and repeat the cycle. The mulberrylike colonies are those usually recognized as the characteristic Rickettsia bodies.

TRANSMISSION.

The ubiquitous dog tick *Rhipicephalus sanguineus* was very early shown by Donatien and Lestoquard to be the vector, a finding which has been confirmed both circumstantially and experimentally by subsequent workers. These ticks were found to be infective at all stages and capable of carrying the infection through the egg stage.

A great deal of importance devolves from the transmission by *Rh. sanguineus,* as this tick is also a vector, not only of the

disease due to *B. canis*, but also of the infections due to *Hepatozoon canis* (non-pathogenic but very frequently found in our smears) and *Rickettsia conori* (non-pathogenic to dogs but the cause of "fiévre boutonneuse" in man). From the clinical point of view the frequent occurrence of mixed Babesia and Rickettsia infections is of great significance.

Clinical Forms and Symptoms.

Carmichael and Fiennes (1942) have differentiated between cutaneous, septicaemic and nervous forms, but, as these tend to merge in most cases, the classification cannot be regarded as a rigid one. Our impression has been that it is essentially septicaemic, with the other forms present in a variable degree. Some of our natural cases have shown skin lesions as flat red erosions involving large areas on the legs, no doubt aggravated by licking. Other workers describe erythematopustular lesions on the inner high and hairless abdomen, resembling the pustules of distemper.

The nervous symptoms have in our cases been manifested as somnolence and mild paraplegia but Malbrant described convulsions, hyperaesthesia, amaurosis and meningoencephalitis in the French Congo form.

In general the symptoms may be summarised as follows: Incubation period varying from 1-3 weeks, high fever, more or less inappetence and dejection, small hard thready pulse, spleen sometimes palpable, superficial lymph glands enlarged, superficial and accelerated respirations, anaemia and possibly slight icterus. Symptoms of uraemia may supervene in protracted cases, or in older animals.

The impression is gained that the variations from septicaemia may reasonably be put down to capillary parasitic embolism, as has been claimed in the case of several protozoal diseases.

The temperature curves in our cases, both natural and subinoculated, have been rather characteristic, showing exacerbations and remissions on alternate days reaching in 5 or 6 days a high peak of 106-107° and then gradually coming down by progressively lower peaks to the normal range in about 12 days. Deviations from this saw-tooth arrangement have usually been due to the mixed infection (with *B. canis*). Other workers have written mostly of sustained high temperatures falling gradually to normal. One feature generally agreed upon is the comparatively long period of subnormal temperature before death. This may last up to 2 days.

The experimentally produced cases so far (some half-dozen) have shown these high temperatures, but apart from transient inappetence, have not shown disturbance of habitus commensurate with such fever. In the natural, tick-transmitted cases, dejection and emaciation have been extreme. Some showed icterus probably the result of secondary hepatic damage.

Our impression up to the present is that the tick-borne disease is very much more virulent than that produced by the syringe. This is in agreement with the experience of Danks (1937) but completely at variance with that of Donatien and Lestoquard (1937) who found no difference in pathogenicity (using 3 different strains), and with that of Neitz and Thomas (1938), using the Kruger National Park strain. Further experiments should clear up this point, at any rate as far as our local strains are concerned. Environment seems to play an important role.

Pathological Anatomy.

At autopsy the following changes are usually noted: anaemia, more or less icterus, tumor splenis with prominent Malpighian bodies, subendocardial haemorrhages, oedema of the lungs, nephritic changes, catarrhal enteritis sometimes with haemorrhages or ulceration, liver congested and large, with peculiar mottling, lymph glands enlarged and oedematous, and erosions of the skin.

Chemotherapy.

Donatien and Lestoquard (1937) found attempts to treat with trypan blue, gonacrine, acaprin and recovered serum to be useless. Danks (1937) treated cases with sulphanilamide with results that he described as promising. Pasquini (1939) found encouraging results in 5 dogs he treated with intravenous injections of 7-10 drops of formalin in 10 c.c. of physiological saline, but he admitted that these results could not be regarded as conclusive. Gillain (1942) of the Belgian Congo used a similar treatment.

Malbrant (1939) considered that only arsenicals (such as N.A.B. and stovarsal) were of use, but did not claim them as specifics.

Carmichael and Fiennes (1942) stated that sulphonamides had proved very successful as a treatment and recommended sulphapyridine per os in a dosage of .25G per kilo daily divided into 4 doses, and continued for 5 days.

We have used Uleron in 4 day courses at a daily rate of .1G per kilo with reasonably good results, but have not undertaken any experimental work in this connection.

Of primary importance in the treatment is the diagnosis, and the elimination of *B. canis* as a complicating factor.

Summary.

1. The new incidence of *Rickettsia canis* infection in dogs of the Pretoria district is reported.

2. The difficulties of diagnosis and methods used, are presented.

3. Details are given of symptomatology and treatment.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 277-279, July, 1947.*

ON THE NATURE OF SOME DISEASES IN CALVES

BY

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Read 3rd July, 1946.

In this short report an attempt will be made to focus attention on one of the most serious problems of animal health in South Africa. Apart from the very heavy losses sustained from premature births due to various causes there is a very high mortality in young calves during the first six weeks of their lives, the extent of which is not generally realised. As these deaths are largely confined to well-bred stock the losses are so much more significant. Although it is not possible at present to assess the total losses sustained from different causes, it is well-known that many farmers have lost as many as 50 per cent. or more of their calf crop during some years from paratyphoid alone.

When a calf is born it has to adapt itself to its surroundings and has to establish an equilibrium with the outside world. The balance between health and disease would, therefore, depend on the nature of the general environmental conditions to which it is exposed. If it arrives and remains in the open veld far removed from places that are contaminated with animal excreta it is unlikely to suffer much from disease during the most susceptible first few months of its life; but if it is born and raised in an unfavourable environment the normal balance between it and its surroundings is disturbed; various micro-organisms, some of which are normally non-pathogenic, become invasive and set up disturbances. Predisposing factors that may be as important as the microbical cause include the general hygiene and the calf husbandry practised, the nature of the food and the intervals between feeding, the type of housing and the climate, and infestation with parasites.

Generally the infection is introduced by means of newly acquired calves, particularly by calves purchased from dairies; but sometimes spontaneous outbreaks are initiated in the premises by unfavourable environmental conditions.

No matter what the cause of the disease is, the digestive and respiratory organs are the most vulnerable and always develop the most extensive pathological changes. On this account the affected calf invariably suffers from diarrhoea or pneumonia or both.

South Africa is fortunately not very seriously troubled with the deadly "white scours" of Europe and America which

destroy only very young calves up to ten days old; but this country suffers a considerable animal mortality from a much more devastating and a far more widespread disease, calf paratyphoid, which affects calves up to 3 months old. This malady is usually acute and generally assumes the form of a septicaemia, resulting in death of the animal within a few days; but sometimes the course is more protracted and pneumonia becomes a common symptom. Although *Salmonella dublin* is considered to be the primary cause of this disease, other bacteria, like *Corynebacteria* and *F. necrophorus,* are frequently associated with the lung lesions and no doubt play an important part in the pathogenesis of the pulmonary changes. Sometimes outbreaks of pneumonia in calves, however, have been studied when *Salmonella dublin* as an etiological agent must be excluded and when either *Corynebacteria* or *F. necrophorus* has to be implicated; more recently a virus has been incriminated.

Calf paratyphoid and calf pneumonia spread most readily by means of manure so that kraals and manure contaminated enclosures are regarded as the most important sources of infection. The local custom of confining calves for several weeks to these places, therefore, accounts for the extraordinary high prevalence of these diseases in South Africa. In tests carried out at Onderstepoort it has been found that paratyphoid infected manure, when dried, will retain the infection for over 900 days.

Both calves and adult cattle act as carriers of these diseases, constantly disseminating the infection by means of their excreta. Dairy products are, therefore, liable to be contaminated with these organisms, and several very serious outbreaks of food poisoning in man have been traced to milk obtained from infected herds. Recently two extensive milk-borne outbreaks of paratyphoid, involving 173 and 150 persons respectively, have been reported by Lewin and Roux in Johannesburg, *Salmonella dublin* being implicated in both outbreaks. Similar outbreaks, probably less extensive, and due to the same cause no doubt occur much more commonly in this country than is generally realised.

For the prevention of losses in calves much more attention should be paid to hygiene, calf husbandry, housing and feeding of the calves. The great advantage of feeding the calf at regular intervals about four times a day, thus obviating the undue overloading of the calf's stomach which is the inevitable result of the usual two feeds, is not generally realised.

In addition prophylactic inoculation against calf paratyphoid has yielded excellent results. In related diseases like calf paratyphoid and human typhoid, however, it is not possible to obtain the same type of immunity as in anthrax and blackquarter, where the immunity can be assessed by the ability of

the animal to resist infection against so many M.L.D.'s of the virulent culture. In *Salmonella* infections the immunity conferred is judged by the length of the period the immunized animal can survive after the injection with virulent culture as compared with controls. In mouse immunization experiments with *S. dublin* it was found that approximately 90 per cent. of the control animals die within 48 hours after receipt of the virulent culture, whereas over 90 per cent. of the immunized mice survive after 48 hours, although the majority of them may die subsequently. In field experiments carried out it was found that the vaccine protects over 95 per cent. of the calves exposed to natural infection.

For the immunization against calf pneumonia *Corynebacterium* toxoids have been tried on a small scale and the results obtained are encouraging.

There is little doubt, therefore, that the tremendous calf mortality can be reduced considerably if prophylactic vaccination is carried out in conjunction with proper attention to the calf husbandry, housing and feeding of susceptible calves.

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PRELIMINARY REPORT ON INVESTIGATIONS CARRIED OUT IN CONNECTION WITH A DISEASE AFFECTING STOCK IN THE NGOTSHE DISTRICT WITH SPECIAL REFERENCE TO NAGANA

BY

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Read 4th July, 1946.

During the latter end of 1945 and in early 1946 disquieting reports of a heavy mortality amongst European- and Native-owned Cattle occurring on farms in the Ngotshe and Piet Retief Districts, gave cause for anxiety and necessitated action being taken by the Veterinary Department.

Before submitting the details of our investigation a brief sketch of the area in which the disease was investigated may be of advantage.

The eastern portion of the Ngotshe district of Natal is a tract of country west of the Lebombo Mountains between the Mkusi and Pongola Rivers. The Piet Retief "Corridor" of Transvaal lies to the north of Ngotshe between the Pongola River and the southern boundary of Swaziland. The following is a very rough description of the country.

In bush conditions this area is similar to the country lying to the south of the Mkusi and may be regarded as typical fly country and suitable for its propagation. In this respect our observations are in agreement with those recorded on previous occasions (1, 2). The locality is very hilly and the wooded valleys are drained by rivulets, which either flow into the Pongola or Mkusi Rivers. The plains are covered mainly with annual grasses which occur in alternating patches of Urochlua and *Digitaria Spp.*, but under the trees patches of "Buffelsgras" (*Panicum sp.*) are more prevalent. During our visit there was a luxuriant growth of the grass reaching a height up to six feet in some areas. It was in full seed but showed signs of wilting.

Along the slopes and especially on the hills the dominant grass is *Themeda triandra* (rooigras). Large portions of this grazing had been burnt during the winter, and the signs of this were still apparent. Various types of trees occur in this area. Several *Acacia sp.* predominate, but a fair number of Combretums and maroela trees (*Sclerocarya caffra*) were present.

Various types of poisonous plants were recorded, but none of them occurred in such quantities as to incriminate them with

this high mortality. Special attention was given to the distribution and prevalence of the senecio-plants and a fair number were seen which apparently belonged to one species (*Senecio bupleuroides*). The plants occurred mainly on the southern slopes of the hills, less frequently on top and a few specimens in the valleys. None were found near the banks of the Pongola on the farm Leeukop on which the first losses had occurred. Large areas of the farm Burgersrust were traversed on foot and the densest patch was found in the vicinity of the dipping tank.

A striking fact was that on several farms along the road to Magut where these plants were very prevalent the cattle were in good condition and showed no signs of the disease. Species of *Senecio latifolius* and of *S. scleratus* were seen, the former predominating.

Of the other poisonous plants in this area species of Gnidia were most widely distributed and occurred in the valleys and on the slopes of the hills often in fairly large numbers. *Solanum pandureaforme* occurred fairly frequently in the valleys and *Adenia digitata* on the slopes of the hills especially on Burgersrust. Several species of Scilla had a varied distribution, as well as Kalanchoe and Cotyledon. Some of the above-mentioned plants may act as irritants to the intestinal tract and as cardiac poisons.

Divergent views were expressed as to the cause of the mortality. As, at that time, the worst drought for 25 years was experienced in this area, several stockowners refrained from reporting the condition. The losses were associated with starvation and poverty, the sequelae of the drought accentuated by the ill effects of overstocking. Soon, however, it became evident that the condition was considerably more serious and as a result of the increase in the mortality, the locality was visited on the 20th October, 1945, by a Research Officer and the local Veterinary Officer. It was found that the general picture, history, symptoms and pathological anatomical changes closely resembled those seen on a previous occasion in senecio-poisoning in the Eastern Cape Province and in experimental animals at Onderstepoort.(3) Subsequently seneciosis complicated with other plant poisons, such as Kalanchoe, Scilla, Urginea and Gnidia species was diagnosed. The negative results of the microscopical examination of the blood and spleen smears were in favour of this view.

The area was revisited on two occasions and in both instances the diagnosis of seneciosis was re-affirmed at autopsy.

In the meantime several outbreaks occurred indicating that the disease was apparently spreading to other farms. The general description of its symptomatology, macro- and micro-pathology closely resembled that of the condition previously seen on Burgersrust. In none of these cases did the histo-pathology

substantiate the tentative diagnosis of senecio-poisoning. It was assumed that the same condition caused the losses on the various farms and an infectious disease was suspected. Material collected during our visit was examined bacteriologically and proved to be negative for paratyphoid.(4)

Investigations undertaken by us at the beginning of April, 1946, revealed the existence of trypanosomiasis (nagana). Trypanosomes were detected by one of us (K.S.) in bloodsmears taken from affected animals on several farms. A point worthy of note is that most of the infections occurred on farms in close proximity to or bordering on the larger watercourses. The outbreaks occurring more inland could be linked with a previous movement of stock to the affected area. It is of interest that on re-examining some of the bloodsmears, taken at the onset and during the course of the disease, trypanosomes could be demonstrated.(5) Thereby conclusive evidence was produced that the disease occurred as early as the beginning of October, 1945, and that the causal organism was found in cases which had been considered clinically and at autopsy as typical senecio-poisoning. The diagnosis of nagana was clinched when, subsequently to our visit, the presence of *G. pallidipes* was established by fly traps on several farms on which nagana had either been diagnosed or suspected.(6)

All stock, horses, mules, donkeys and cattle, and even dogs were susceptible to the disease, which in most cases had a fatal course. Young stock and especially calves appeared to be more resistent to the disease than adult cattle. Nothing definite can be said of cats and pigs as they were comparatively rare in this area.

The disease was successfully transmitted to four out of five animals after subcutaneous injections of jugular blood from suspected cases. The animals involved were a young cat, dog and two Africander grade oxen. Trypanosomes occurred fairly frequently in the bloodsmears of these animals, but they were never detected in the bloodsmears taken daily for a considerable period from the fifth case, a dog, which remained healthy. Of the affected animals the cat and dog succumbed to the disease 16 days after subinoculation. One bovine was killed and the other showed no clinical signs of the disease up to the present. Recently the number and size of trypanosomes in its bloodsmears were appreciably reduced. Trypanosomes were also present in the conjunctival smears from one of the experimental dogs. The trypanosomes were polymorphic and *T. congolense* and some forms resembling *T. brucei* have been identified. The former appeared considerably more frequently in the bloodsmears than the latter, especially in the cattle which had been subinoculated with the blood from diseased animals.

Evidence of a dual infection was further confirmed by the application of serological tests.(7)

Trypanosomes are frequently easily identified during the earlier part of an infection, but as the number of the parasites becomes considerably reduced in the circulation, it is not always possible to verify the diagnosis by microscopical examination. This was the case at the onset of the disease, and the inability to demonstrate the trypanosomes can be fully appreciated.

These are probably some of the factors responsible for the delay in diagnosing nagana earlier.

The changes observed in the livers, prior to our visit, were more or less consistent, but varied in extent and degree and were not indicative of senecio-poisoning. In no case was there an increase in the intralobular connective tissue of the liver, a sign of chronic seneciosis. The red foci, typical for acute seneciosis, are formed by blood pools or lagoons resulting from stasis of a varying degree in the central veins as well as in all the different affluent capillaries,(8, 9) whereas in the case of nagana the striking feature is a venous stasis as a result of thrombosed bloodvessels. Two types of lesions are recognised, areas either in which signs of necrosis predominate or in which infilteration of cellular elements are more in evidence. Degenerative changes and inflammatory cellular infiltrations have been observed in the myocard, in the musculature of the hindlimbs and the diaphragm. In the brain sections of an animal which had shown nervous symptoms no rickettsiae could be found, but the lumen of some of the bloodvessels contained structures, which resembled fragments of trypanosomes.

The mortality varied to some extent on the various farms, but there is no doubt that it was considerable in some localities. On the farm Sunlands, for instance, all the native stock which had been left behind succumbed. A mortality of about 50 to over 80 per cent. could be recorded on other "affected" farms.

Nothing definite can be stated about the incubation period, but there is evidence that apparently healthy stock showed the first symptoms 3 to 4 weeks after coming in contact with visibly affected animals. The former may have harboured the trypanosomes in the bloodstream without showing signs of the disease. Periods of 1 to 3 months have also been mentioned. One of the experimental bovines has been showing a trypanosome infection in the bloodsmear for about two months. It is still apparently healthy. The incubation period may possibly also vary considerably under natural conditions, depending on the nutritional state of the animal and the exact time of its infection.

There is a great difference in the duration of the disease in cattle, a few will die within a week of showing symptoms, many die within a month, and others linger on for six months

or longer. Only a very small percentage may recover. Sudden deaths have been known to occur.

The symptomatology may vary, depending on whether the disease is in its acute, subacute or chronic form, and the type of animal affected. It is usually characterized by a gradual loss of condition, staring coat and severe anaemia, lachrymation and salivation. There is apparently no rise in temperature and if a hyperthermia is recorded it may be associated with external influences. A striking feature of the disease in cattle was a marked enlargement of the prescapular and precrural lymph glands, which could be seen quite easily at a distance. This phenomenon also occurred in cattle on farms in the vicinity of "affected" ones, where no losses had been reported.

The post-mortem appearances were more or less consistent with varying degenerative changes in the liver, which at one stage were confused with those of seneciosis. The following conditions were also observed: Enlargement of the spleen and the lymphatic glands, pronounced hydropericard, hydrothorax, slight or absent, and a varying degree of ascites and gastro-enteritis, subendocardial haemorrhages, congestion and infarcts in the cortex of the kidneys and degenerative foci in the adrenals.

At the onset of the outbreak several diseases were suspected as likely causes, for instance, (*a*) infectious diseases like anthrax or any of the tick-borne diseases. These, as a result of negative bloodsmear reports, could easily be eliminated as primary causes, and in the case of heartwater the causal organism was not found in intima smears or in brain material. (*b*) Starvation, the sequelae of drought, was held responsible for a number of the losses during the drought and the beginning of the rainy season, and in some cases no attempts were, therefore, made to report the severe losses. However, after the veld conditions had considerably improved and the mortality did not abate and a number of animals continued to lose condition, it became evident that another factor had to be incriminated.

(*c*) The effects of poisonous plants, especially seneciosis, could definitely be excluded as primary causes, for the previously mentioned reasons as, for instance, the apparent lack of senecio-plants and the histological evidence.

(*d*) It was reasonable to suspect the lack of some essential element or elements in the feed during the dry season, and the eating of earth by some of the animals was in favour of such an assumption. However, after the improvement of the veld conditions, this view could not be adhered to any longer, because the severe mortality continued.

(*e*) Arsenical poisoning could be excluded after a negative result of the chemical analysis of certain organs was obtained.

(*f*) Even Rinderpest was considered as a possible cause, especially when the extremely high mortality was taken into account. However, no evidence was obtained that the disease was transmitted by direct contact. No fever was present in the animals temperatured, and the apparent higher resistance of the calves compared with that of the adult animals was not in favour of this view.

(*g*) Although the majority of animals autopsied showed a fairly heavy infection of wireworm (*Haemonchus contortus*) and nodular worm (oesophagostomun), verminosis was not considered the primary, but probably a contributory cause. Contrary to the experience in verminosis, the adult cattle were the first to succumb, and the mortality continued after the stock had access to luxuriant veld conditions.

It does not lie in the scope of this publication to discuss the probable causes responsible for the epizootic form of the disease in detail, but a few of the concurrent contributory factors will be dealt with briefly as follows:

Owing to the severe drought an acute water shortage occurred over large tracts of land which were rendered useless for grazing purposes during the dry months. Cattle owners were compelled to migrate with their cattle to other grazing grounds, situated in the vicinity of the larger rivers. Tsetse probably occurred fairly frequently here in view of the severe mortality which followed.

Local evidence was obtained that during that period there was a temporary influx of game into that locality. Wildebeest and zebra were seen on several farms for the first time after a number of years. On the banks of the Pongola large numbers of wild pig were seen which at one time became very weak and could be easily killed by the natives, probably as a result of the effects of the drought. This increase of game not only placed an extra burden on the already overstocked areas, but its prevalence in that area, undoubtedly, aided in the spread of the disease. It is a known fact that game may harbour trypanosomes without showing signs of the disease. The presence of trypanosomes has been established in the kudu, buffalo, bushbuck, wildebeest, hyena, reedbuck, steenbuck (Bruce 1895, 1903), impala, bushbuck and zebra (Mitchell, 1914), duiker, warthog(1); bushbuck, kudu and zebra(10, 11), warthog, bushbuck, kudu, steenbuck, duiker(12).

The sequelae of the drought, the rains following, overstocking, and the effects of other diseases occurring concurrently with nagana may have contributed in producing the epizootic form of nagana in this area. This group of factors probably lowered the vitality of the animals considerably and, consequently, they became more susceptible to nagana and other diseases.

CONCLUSION AND SUMMARY.

Conclusive evidence was produced that:

(*a*) Seneciosis could not be regarded as the primary cause of the severe outbreak.

(*b*) Nagana was present since the outbreak at the beginning of October, 1945, and probably earlier.

(*c*) The possibility of nagana becoming enzootic in this area has to be borne in mind.

(*d*) Although an outbreak of the disease was reported in October, 1945, there appears to be some evidence that isolated cases may have occurred on several occasions earlier.

(*e*) Other complicating factors such as the sequelae of the drought, other debilitating diseases caused by external or internal parasites, and tick-borne diseases, possibly contributed directly or indirectly to the losses. This group of factors may have reduced the vitality of the animals and increased their susceptibility to diseases like nagana.

(*f*) There is probably evidence that *G. pallidipes* increased in numbers in this area prior to the outbreak at the beginning of October and had spread in a westerly direction along the large rivers and their tributaries. It has encroached on to farms formerly considered not to have been infected. The danger of the disease spreading to other potential fly areas should not be lost sight of.

(*g*) Mechanical transmission although not usual may take place under certain special conditions.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 287-294, July, 1947.*

SCHISTOSOMIASIS IN SOUTHERN AFRICA IN ITS RELATION TO RAINFALL, ARTIFICAL METHODS OF CONTROL AND THE NATURAL ENEMIES OF THE MOLLUSCAN HOSTS

BY

DR. F. GORDON CAWSTON.

Read 2nd July, 1946.

Reconsideration of the control of Schistosoma in the light of South Africa's recent drought has fostered a new outlook on scientific procedure and may serve to modify the policy of health control.

RAINFALL.

South African rivers are subject to violent fluctuations and the effect of rainfall on animal life is not easily determined. Floods wash much debris into the sea but fish and snails escape behind stones and in mud or are found in overflow pools.

I have collected *Physopsis africana* Krauss, *Lymnaea natalensis* Krauss and *Bulinus forskalii* Ehrenb. in lagoons but only shells of Gulella, a terrestrial genus, among debris on the sea-shore though I have watched grunters swallowing Lymnaea and Biomphalaria.

Anti-mosquito measures are not considered of importance in destroying vegetation, molluscs, mammals and birds or even fish but little note has been made of the effect of varying rainfall and wind on the incidence of Schistosoma in the Union and Rhodesia.

One effect of drought is the distortion of shells, thus causing confusion in identifying molluscs. This is particularly true of Bulinus, a notoriously polymorphous genus, but is observable in species of Lymnaea especially where found above the water edge.

Absence of rains would account for the large ill-shaped shells of Lymnaea on marshy land at Rustenburg in 1916 and may explain what resembled shells of *Bulinus schackoi* Jickeli among typical *Bulinus tropicus* (Krauss) at Potchefstroom.

To avoid confusion with imported species note should be made of specimens collected in open rivers, stagnant pools or private aquaria. Mr. Hugh Watson has identified an Australian species from Durban which Major M. Connolly terms *Linameria dispar* Sowerby.

In 1945 at the Natal Coast half the rain fell in February and March and very little rain fell during the winter so that many molluscs must have been washed down-stream in these two months when they breed profusely under normal conditions.

Not until October in 1945 was more than one inch of rain recorded and an average of only approximately two inches a month fell during the next two months. Not for thirteen years has such a prolonged drought been experienced in Natal and elsewhere.

Fish, small mammals, water insects and snails have suffered from disappearance of the shade of vegetation along rivers, and such other natural enemies of pond-snails as crabs, birds and lizards have likewise become less.

Mr. C. Sutton says he has never seen so little water in our rivers, trout being considerably reduced through lack of rain in the spring of 1941 and trout scales in Natal showing poor growth in some more recent periods.

During the last eight years 29 consecutive rainless days were recorded at the Sugar Experimental Station of Mount Edgecombe once (in 1945), but twenty days or more occurred eleven times. However, humidity up to 90 per cent. would allow for reduced rains. At Salisbury, Southern Rhodesia, during the last twenty-five years continuous absence of rain was noted only from February 11th to March 12th in 1934 but some twenty days' absence occurred seven times. The effect on Schistosoma deserves investigation. Exceptionally heavy rains often succeed a dry season. In 1922-1923 the annual rainfall at Salisbury was 45.41 inches but it was only 17.08 inches in 1923-1924 whilst the total for three years from 1935 was under thirty inches annually.

Besides Succinea and Lymnaea I have noted Bulinus, Ancylidae and even *Physopsis africana* Krauss attached to rushes above the water level near the coast, where they would be safe from chemicals introduced into the stream.

Pond-snails are uncommon in pools exposed to strong sunlight or wind though I have found *Physopsis africana* Krauss, *Biomphalaria pfeifferi* Krauss and *Lymnaea natalensis* Krauss crawling on sand in shallow water exposed to sunlight.

Where aquatic plants can resist the river currents pond-snails abound but vary in numbers with the rise and subsidence of rivers and with the amount of decaying matter and mineral content in the silt of rivers and their tributaries.

In desert country, as after drought, much water evaporates and pond-snails lessen. In swampy areas where there is much organic matter in suspension pond-snails become numerous as during a normal summer season.

Artificial interference may have but a temporary effect because of the natural recovery of a district following rains which bring down-stream suitable surface vegetation, as has been noted in the Egyptian Nile.

The influence of high and low temperatures on the development of Schistosoma has been carefully studied but little note has yet been recorded of the influence of different seasons of the year on varying rainfall and winds on their cercariae.

PHYSOPSIS.

Physopsis, like *Melanoides tuberculata* Müller, readily subsides into mud and is less influenced by uncongenial environment than its allied snails. Though more commonly frequenting the surface in cooler districts, the shell is easily dislodged.

During the last few years whilst other species have largely disappeared from Natal rivers along with their favourite foods *Physopsis africana* Krauss remains prevalent and is often the only species easily collected.

Physopsis is most common in stagnant pools contaminated with human excreta, as hosts for *Schistosomum japonicum* prevail in land inundated for part of the year and exposed to continuous infection from labourers at other seasons.

Without the normal rains in 1945 Physopsis remained in river pools and measured up to twenty millimetres at Inchanga, Natal, but many large specimens remained uninfected until rains washed pollution into the streams.

It is unfortunate that records of the proportion of snails harbouring schistosomes at various seasons are not available to reveal occasional hosts and seasonal predisposition to infection with trematode worms.

At Clairwood, Durban, there were exceptionally few snails in an infected pool in May, 1946, but greedy attacks of Gambusia around a specimen of *Physopsis africana* Krauss harbouring a tadpole cercaria prompted investigation.

Showers of larvae emerging from an infested Physopsis from Inchanga and floating head downwards but seldom reaching the bottom of a test-tube disappeared when a small Barbados fish was added to the water.

A few hours later the fish was surrounded by cercariae from the snail, as if incapable of dealing with so many, and two specimens of *Lebistus reticulatus* were added to water rendered cloudy by hundreds of *bifid* tailed larvae.

Within half an hour the water was clear as a result of the fish's rapid movements or feeding, any cercariae escaping from their gills probably losing their tails and dropping to the bottom of the water, but showers of cercariae still continued.

A test-tube containing numerous larvae in the water was well shaken to observe the effect of strong disturbance of water in the natural state. This resulted in swimming larvae being confined to the bottom of the water.

The great number of parasites escaping from an individual snail at the commencement of winter suggested that it would be ripe for serving as food for such scavengers as frequent river pools.

Among animals attacking snails have been recorded beetles, worms, flies, birds, frogs, toads, mice, rats, the iguana and mongoose and, among fish, the Gillaroo trout, the eel, barbel, gold carp and roach in the United States.

I noticed that when small fish were placed in water containing living cercariae they were specially attracted to the immediate surroundings of a specimen of Physopsis from which the cercariae were escaping.

Heavy rains at Christmas 1945, washed snails downstream but would wash infection into pools and, close to Physopsis in a river pool, I observed human excreta on stones in the river bed at this time of the year.

Pools without outlet may become too stagnant and overgrown for infected snails to be found. Where none are seen on growing waterplants I have sometimes obtained them on a floating banana or cabbage leaf.

Physopsis is seldom found close to tadpoles, partly because they are eaten by frogs, but I have seen a tadpole killed by the forcible pressure of a specimen of Physopsis on its crushed tail.

ARTIFICIAL METHODS OF CONTROL.

Adequate medical inspection of children and adults of all races is essential to determine the incidence of Schistosoma and its variation due to abnormal weather conditions influencing the molluscan hosts in any locality.

I have watched tadpoles escaping to the water edge from Ross's larvicide but chemicals cannot be evenly distributed through a pool especially where there is any inlet and outlet and snails adhering to rushes may escape.

Road construction inevitably dries up springs of water but, unless the soil is completely dried or coated with cement in channels which only too frequently become choked with vegetation and algae, the springs may reappear later.

Severe pollution of river banks suggests complete clearing of vegetation and "burying in" of the soil, as by a combination of scraper and tractor for land clearing and road construction, thus temporarily removing much litter and undergrowth.

I have found natives with schistosome ova in the urine at work among sugar, beside a stream draining into a large lake adjoining a military camp and close to a large native village. Here such ploughing was strongly indicated.

Deep water or a good running stream seldom requires interference and, where complete clearance is difficult, Natal Indians

have sometimes "buried in" pools covered with Eichhornia and used the land for gardens instead of swimming.

SURVIVAL OF SCHISTOSOMES AND SNAILS.

Though schistosomiasis is less serious to-day schistosome carriers have not decreased in some districts in spite of precautions, and where such parasitic diseases persist some obscure factors in prophylaxis must have been overlooked.

The most convincing reports of successful control have come from countries where the native carriers have been carefully cured and the pollution of river banks has been overcome by the removal of rushes and the application of lime.

Schistosomes occurring in Southern Africa include *Schistosomum haematobium* Bilharz, *Schistosomum mansoni* Sambon, *Schistosomum bovis* Sonsino and *Schistosomum spindale* Montgomery. This last is claimed to cause nasal infection in Indian stock.

The comparatively little haematuria associated with any of these parasites except *Schistosomum haematobium* Bilharz with the small spine to its ovum shows that the schistosome spine has nothing whatever to do with the causation of haemorrhage.

Antigen prepared from the liver of infested snails would seem to apply to all schistosomes and even Fasciola. It is therefore useful as a confirmatory test where positive, but negative results are of little avail in diagnosis.

OVA.

Before a total of half a gramme of antimony metal or the equivalent of emetine is reached for destroying schistosomes in the final host, normal shaped but dormant ova, continue to escape and may hatch when the drug is washed off the shells.

Schistosome ova are known to survive in human excreta for ten days, and six weeks later cercariae will escape from the snails they infect. With normal November rains infection is most likely to occur in Natal from January to May.

MOLLUSCAN HOSTS.

Professor W. W. Cort once acknowledged that *Melanoides tuberculata* Müller had reached him alive by post from Durban. This operculated species is unrelated to human disease in South Africa and its shell is a dextral one.

In 1945 I collected for Commander J. M. Amberson, R.N., U.S.A., *Lymnaea natalensis* Krauss, *Biomphalaria pfeifferi* Krauss, *Physopsis africana* Krauss and *Bulinus tropicus* Krauss which reached Cairo by air alive, some surviving the trip to Maryland, U.S.A.

This shows a new way in which molluscan hosts for human and stock parasites may be introduced into places. Air mail

avoids the inconveniences experienced when Melanoides and Physopsis were brought me from Nyasaland.

CERCARIAE.

Among larval schistosomes floating in test-tubes on cold days I have observed normal swimming movement for fifty-seven hours. Tailless cercariae sink whilst some species encyst on grass till eaten by stock.

Seasonal infestation of snails has been studied in Egypt and A. G. Barlow considers that infection is unlikely in winter though the fewer snails available harbour cercariae, infestation largely corresponding with temperature.

Without tails schistosome cercariae may crawl along a surface but are less likely to reach the final host, and water drawn from the bottom of a well is unlikely to include cercariae or their snails such as would infect domestic water.

This explains why persons seldom, if ever, contract schistosomiasis except from an open pool, intake pipes protected from the entry of snails leading to pumps where rapid disturbance of water would destroy many cercariae.

Schistosome larvae are fragile and readily shed their tails though *Heterophyses heterophyses*, a brackish water organism, favours the bottom of water. They cannot encyst like those of Fasciola which resists desiccation on grass.

No one can tell that fish are absent from a river merely by examining a bottle-full of the water, and samples of water obtained from a pool are unlikely to reveal recognisable schistosome larvae unless a snail carrier is obtained.

Oils for destroying mosquito-larvae would help to destroy cercariae but engineering structures of permanent value which would destroy them by mechanical means are to be preferred to chemicals which may injure other animal life.

Of 764 species of non-marine molluscs in Southern Africa only about seven are known to be common carriers of trematode infection of man, and wholesale destruction of molluscan life on a farm should never be countenanced.

NATURAL ENEMIES OF MOLLUSCAN HOSTS.

Drying up of water holes has exposed many rare species of game, and natives with their dogs driven to desperation in search of food have caused much destruction.

Natural enemies of Physopsis are disappearing but bore-holes might well be further used to encourage wild life and vegetation fostered along river courses, to encourage the shade of river banks for all kinds of animal life.

Clear river water is promoted by natural vegetation along the banks where the natural enemies of disease carriers find shelter, and water for domestic use can usually be pumped from pools where the banks are lined with vegetation.

At Greytown a large lake is surrounded by a fence and supplies wattle farms as well as the town. I noted little water plants there in April but collected *Lymnaea natalensis* Krauss. No artificial purification is required.

In rural areas a river should have natural vegetation along its banks but, on passing through towns, it is better canalised provided the channel is kept free of refuse. Where badly polluted a river should be temporarily diverted.

At Umzinto in March, 1946, I noted much overgrowth in the stream, the artificial channel being choked with vegetation so that casual attempts at mosquito-destruction in the water were unsatisfactory.

I collected *Bulinus forskalii* Ehrenberg measuring twelve mm. in the open stream along with *Physopsis africana* Krauss. Though early to expect infestation the large dimension may well be explained by the recent drought.

Natural enemies do not exterminate a favourite food, and pond-snails are valuable helps in water purification except in those seasons when they harbour infection of man or stock though potential carriers alone require control.

Fish and birds sometimes discard a well-developed snail and I have seen fish nibbling at a snail rather than swallowing whole a shell which showed some chemical change, whilst other snails were swallowed in their shells.

Inability to distinguish the various snails and cercariae has resulted in unnecessary destruction, but *Bulinus forskalii* Ehrenberg, a readily infested host, has escaped due examination in seasons of the year when infection is usual.

Biomphalaria commonly harbours Schistosoma in warm localities but is seldom infected further south and Bulinus which abounds amid cattle dung on vleis seldom carries schistosomes in South Africa.

It is time that such archaic terms as "Isodora" and "Bulinus" passed out of literature dealing with South African disease carriers and that illustrations of the shells and cercariae were more carefully made.

Conclusions.

Like other disease carriers Physopsis should be protected at certain seasons of the year, the fragile cercariae and human pollution of rivers being dealt with.

Larval schistosomes are fragile organisms favouring surface water and can be avoided by drawing water from deep wells or by forced disturbance of water.

Rainfall detaches Physopsis from vegetation and carries specimens into the mud. It also causes infection by washing human excreta from stones in river beds into the water.

Drought lessens natural enemies of molluscan hosts which attain uncommonly large size where, under natural conditions, they would have been swept downstream.

Some molluscs crawl out of flood water and some survive for months attached to rushes during a drought but Physopsis is the only common carrier of Schistosoma in South Africa.

Normal water courses should be preserved with their natural vegetation, for fishes, birds, crabs, insects and mammals might be injured by the use of chemicals to control Schistosoma.

A low rainfall may be expected to increase the incidence of Schistosoma but a prolonged drought reduces it by causing a disappearance of the natural food of molluscan hosts.

Common carriers of trematode infection including Physopsis have travelled alive from Durban to the United States showing a new way in which disease carriers may be introduced to a locality.

In South Africa molluscan hosts for schistosomes do not readily withstand desiccation, and windy seasons hasten the death of ova on river banks.

It is difficult to believe that schistosomiasis can be imparted in a stream well stocked with fish especially with those which like snails and cercariae.

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FOSSIL MAMMALS FROM THE MAKAPAN VALLEY, POTGIETERSRUST. I. *PRIMATES*

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With 7 Figures.

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INTRODUCTION.

In July and December, 1945, and again in May, 1946, groups of students from the Department of Anatomy of the Witwatersrand University collected a large number of mammalian fossils from the limestone breccias of the Makapan Valley. Most of these, including the specimens described in this paper, were recovered from the dumps of an abandoned lime-works at the entrance to the valley. The deposits from which this material was quarried seem to have been almost completely worked out, only a little breccia similar to that which contained the fossils remaining *in situ.* The geological age has not yet been established.

Previous to our visit no Primates had been recorded among the fossils from this area. Among the specimens recovered in July, 1945, a baboon mandible was assumed to belong to an unknown extinct species which has since been described by Broom and Jensen. The material obtained in December included good skulls of two Cercopithecid Primates. One of these belongs to an extinct genus and species previously recorded only in the Sterkfontein deposits; the other is entirely new. It is to be noted that these speciments were found in different dumps and embedded in quite different types of breccia.

DESCRIPTION OF SPECIMENS.

1. *Papio Darti,* Broom and Jensen, 1946.

The type mandible of this species was embedded in a mass of red sandy breccia. It is described by Broom and Jensen in the paper already mentioned. No further description of it is necessary, and no additional material of this species has been identified.

2. *Parapapio Broomi,* Jones, 1936.

This genus and species were named by Jones to contain the Cercopithecid Primates from the Sterkfontein breccias. Unfortunately, as Broom (1940) points out, Jones selected as his type

specimen an imperfect skull in which the dentition is very poorly preserved. Broom has redefined the dental characters of this species, but so far no further account of the skull has been given.

A skull from the Makapan Valley (A.D. 1326-2) can be referred without doubt to Jones's species. It was embedded in a soft yellowish clayey breccia. The facial portion of the skull is nearly complete except for the premaxillary alveolar margin and the zygomatic arches; the anterior portion and roof of the braincase are also well preserved. Although the incisor and canine teeth are lost, the cheek teeth on both sides are excellently preserved except for the right first premolar and the hinder half of the left third molar. From the form of the canine alveoli the skull is certainly that of a male, and since even the third molar is appreciably worn this individual must have been fully adult.

The appearance of this skull is clearly shown in the accompanying illustrations (Figs. 1-4). In size and form it corresponds very closely with Jones's type specimen of *P. Broomi,* but in many features it is more complete than the type or any other described specimen from Sterkfontein.

Firstly, as in Jones's type specimen, the supra-orbital margins are delicately shaped and a supra-orbital torus is completely absent. Thus if looked at from the front, the supra-orbital regions do not, as in *Papio ursinus,* conceal the frontal portions of the braincase.

The anterior surface of the zygomatic bone shows a steep backward and upward slope which is responsible for the backward displacement of the lower border of the orbit. However, in this specimen the lower border lies behind the last molar and not anterior to it, as stated by Jones for the type specimen.

In this skull, as in the type specimen, the muzzle is relatively short and high arched; the nasal bones, meeting each other at an angle accentuate the arch. Further, when compared with the condition in Papio, the lateral surface of the maxilla shows only a slight degree of excavation. The profile of the muzzle is typically almost straight from the glabella to the extremity of the nasal bones and shows no infraglabellar depression of the bridge of the nose. The temporal lines do not reach the midline and are practically identical in shape with those of the type specimen.

In addition, this skull reveals a number of features not demonstrated by Jones's material. The nasal aperture is oval in shape and relatively elongated. Its lateral boundary is formed by a process of the premaxilla. As in *Papio ursinus,* this process extends up between the nasal bone and the maxilla for only a short distance, whereas in Cercopithecus the premaxillary process extends nearly up to the naso-frontal suture.

While the lateral surface of the maxilla is slightly hollowed out, this excavation does not extend on to its zygomatic process. Consequently, the lower border of the zygomatic process and of the body of the zygoma is thick and rounded, unlike the condition in most modern baboons. This border lies directly above the anterior cusp of the third molar. In this specimen the orbits are not circular, as stated by Jones, but tend to be heart-shaped with the apices pointing downwards and medially. The supra-orbital notches are large and well-marked and the upper margins or the orbits are decidedly everted.

Finally, the palatal region of A.D.1326-2 is particularly well preserved. The premolar-molar region is conspicuously convex outwards, while the anterior portion of the arcade is narrowed, so that it has a somewhat compressed horseshoe shape. The palate itself is smooth and arched. The palatine foramina open into deep hollows in the postero-lateral part of the palate. Between these hollows the median portion of the palate forms a smooth rounded torus. These features of the posterior portion of the palate are also indicated in the type specimen. The teeth do not deviate from the Cercopithecid type and require no further description here. The premolar-molar length is 45 mm. and the molar length 31 mm.

Discussion.

From this specimen it has been possible to define more exactly the cranial characters of *P. Broomi*. This information permits the generic characters of *Parapapio* to be restated.

The original diagnosis of this genus given by Jones (1936) is as follows:

(*a*) A short muzzle and face.

(*b*) No super-ciliary ridges and feebly-developed supra-orbital prominences.

(*c*) Reduced third molar teeth.

(*d*) Very slight antero-posterior elongation of the first and second molars.

(*e*) The brain has a simple sulcal pattern and an oval contour.

The value of the last criterion may be considered questionable. To this diagnosis the following points may be added:

(*f*) The dental arcades are horseshoe shaped, markedly convex at the premolar region; the palate is deep and smoothly arched and the palatine foramina are set in deep hollows.

(*g*) The zygomatic process of the maxilla shows no hollowing out, and the lower border of the zygomatic process and of the body of the zygoma is rounded and thick.

At least two other fragments from this locality can be referred to *P. Broomi*. One of these is a fragment of mandible with the second and third molars, kindly presented to the Anatomy Department by Dr. K. H. Lepehne of Potgietersrust. These teeth occlude very well with those of the skull just described, and also correspond with the descriptions of the lower teeth of *P. Broomi* by Jones (1936) and by Broom (1940). An upper dental arcade, lent to me by Dr. Broom (Transvaal Museum 1452) is probably that of a female of this species. It is embedded in red sandy breccia of a very different nature from that in which A.D. 1326-2 was found. Thus the remains of *P. Broomi* occur in at least two types of deposit in this area.

The identification of *P. Broomi* is of particular importance as showing that some part of the deposits in the Makapan Valley corresponds broadly in age with those of Sterkfontein.

3. *Cercopithecoides Williamsi*, gen, et spec. nov.

The type of this new genus and species (A.D. 1326-3) is a well preserved skull and complete but fragmentary mandible developed from a block of red sandy breccia. In form this specimen is absolutely different from any living or fossil species with which I have been able to compare it.

The skull is almost complete, although the occipital region is crushed and the bones of the vault extensively eroded. The skeleton of the face is practically perfect and undistorted. The mandible lacks its left ascending ramus and is broken at the symphysis; the remaining portions tended to disintegrate during development to a much greater extent than did the skull. The skull is that of a very old individual, the teeth being extremely worn and in consequence tending to disintegrate; from the size of the upper canine it is certainly a male.

As can be seen in Figs. 5 and 6, the distinctive feature of this skull is the combination of a braincase equal in size to that of *Papio ursinus* with an extremely short muzzle. The length of the braincase falls just short of the average length determined by Goldblatt (1926) for old *Papio ursinus* males, but within the range for the young males.

The supraorbital regions are moderately developed with some indication of a transverse supraglabellar groove. Due to the marked erosion of the skull bones both temporal lines have been lost. The crushing of the occipital region makes it unwise to attach much value to its present structure. It is clear, however, that the superior nuchal line is drawn out into a prominent flange.

One of the most conspicuous features of the skull is the short and extremely deep muzzle with a slight hollowing of its lateral surface below the orbits. In addition the zygomatic processes of the maxilla do not slope backwards, but spread out

laterally and create between the lateral surface of the muzzle and the portion of the face below the orbits, a much sharper angle than is found in either Cercopithecus or Macaca. Because of this, the anterior surface of the body of the zygoma faces forwards and the bizygomatic breadth is relatively increased. The body of the zygoma is pierced by a single foramen. The ridges formed by the canine roots are very prominent. This feature provides the muzzle with two anterolateral angles and gives the dental arcade a rectangular appearance. In consequence of the depth and shortness of the muzzle the anterior surface of the maxilla slopes very steeply downwards. In comparison with other ape skulls it is clear that the maxilla is also transversely narrowed. Each maxilla is pierced by three infra-orbital foramina on each side. They are relatively further from the infra-orbital margin than in Cercopithecus.

The shape of the premaxilla also warrants some consideration. In other baboon and monkey skulls examined, the anterior surface of the premaxilla is thrust forwards in a marked convexity between the two canine roots. In this specimen, however, the anterior margin forms a practically straight line between the two canine roots. This character contributes in no small way to the antero-posterior shortening of the muzzle. The two processes of the premaxilla are very short and narrow, extending only halfway up the sides of the nasal aperture.

The teeth are remarkably small and are very crowded. Thus there is no diastema between the anterior premolar and the canine as appears in Macaca and Cercopithecus. The third premolar is noteworthy in that its crown enamel does not extend on to the lateral surface of the antero-lateral root. The incisors and canines are also reduced in size. The canine has the typical groove on its anterior surface. The incisors appear bunched together below the nasal aperture, so that there is a fairly wide diastema on either side between canine and second incisor. The two sides of the dental arcade are practically parallel, and because of the shape of the premaxilla the part of the arcade between the two canines is almost straight, much as in Simopithecus (Leakey, 1942). Consequently the dental arcade is almost rectangular.

The mandible (Fig. 7) is delicately constructed. The ramus slopes backwards as in Cercopithecus, but is relatively high and broad. The coronoid process is curved backwards and the sigmoid notch is deep. Practically none of the hollowing out of the lateral surface of the ramus so characteristic of the modern baboons is present here. The most distinctive features are in the region of the junction of the ramus and body. The anterior edge of the ramus, instead of merging into the alveolar portion of the body, continues downwards as a prominent ridge almost to the lower border of the body. In addition, there is a

wide groove between the lower part of the anterior edge of the ramus and the last molar tooth. This is probably due to the narrowness of the dental arcade. The teeth are so fragmentary that it is impossible to discover whether this specimen lacks a talonid cusp in the last molar as do the members of the genus Cercopithecus.

Discussion.

Judged by the dimensions of the braincase, this fossil ape must have been comparable in size with the large modern baboons. In the general form of the skull, however, it resembles much more nearly the species of Cercopithecus and Macaca. The shortening of the muzzle is indeed even more pronounced than in these genera, this is due chiefly to the marked abbreviation of the premaxilla. The dental arcade seems also to be narrowed, as well as shortened, to a degree unusual in the Cercopithecidae. This reduction of the muzzle in proportion to the size of the braincase causes the skull to simulate those of the Anthropoid apes, while retaining the essential diagnostic features of the Old World Monkeys.

The depth of the muzzle suggests a comparison of this fossil with the living East African genus Theropithecus and the fossil Simopithecus. So far as can be judged from published illustrations, the similarity is not close, and certainly does not warrant including the South African fossil in either of these genera.

Several features of the specimen resemble those characteristic of the genus Cercopithecus. Besides the proportions of the muzzle, these include the structure of the infra-orbital regions and the shape of the orbits, and also the shape of the posterior part of the palate. Apart from its greater size, however, the skull diverges widely from Cercopithecus in many of its features, and most certainly belongs to a different genus.

It seems necessary, therefore, to create a new genus for this fossil type. The name Cercopithecoides has been proposed on account of the general resemblances of the fossil to Cercopithecus, without implying a particularly close relationship between the two genera. The diagnostic features of this new genus are:

(*a*) Size comparable with the large modern baboons;

(*b*) extremely short, narrow and deep muzzle, reduced and greatly abbreviated premaxilla;

(*c*) crown enamel of anterior premolar not etxending on to the buccal surface of the antero-lateral root;

(*d*) anterior region of mandibular ramus considerably lateral to third lower molar, and extending downwards towards lower border of body.

The specific name *C. Williamsi* is proposed in honour of Mr. E. W. Williams, Senior Technician in this Department, who

collected the type skull during our second visit to the Makapan Valley.

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ABSTRACT.

From material collected by students of the Department of Anatomy, University of the Witwatersrand, from limestone breccias of the Makapan Valley, a new species of baboon *Papio Darti* Broom and Jensen, has already been described. Two additional primates are now identified, namely, *Parapapio Broomi* Jones, previously known from Sterkfontein, and the skull of a new genus and species *Cercopithecoides Williamsi*. This genus is comparable in size with the large modern baboons, but the skull resembles much more nearly Cercopithecus and Macaca.

ILLUSTRATIONS.

Fig. 1.—*P. Broomi*. Norma Basalis.

Fig. 2.—*P. Broomi* Norma Facialis.

Fig. 3.—*P. Broomi*. Norma Lateralis.

Fig. 4.—*P. Broomi*. Norma Verticalis.

Fig. 5.—*C. Williamsi*. Norma Facialis.

Fig. 6.—*C. Williamsi*. Norma Lateralis.

Fig. 7.—*C. Williamsi*. Lateral view of mandible with mandible of Cercopithecus (dotted line) superimposed.

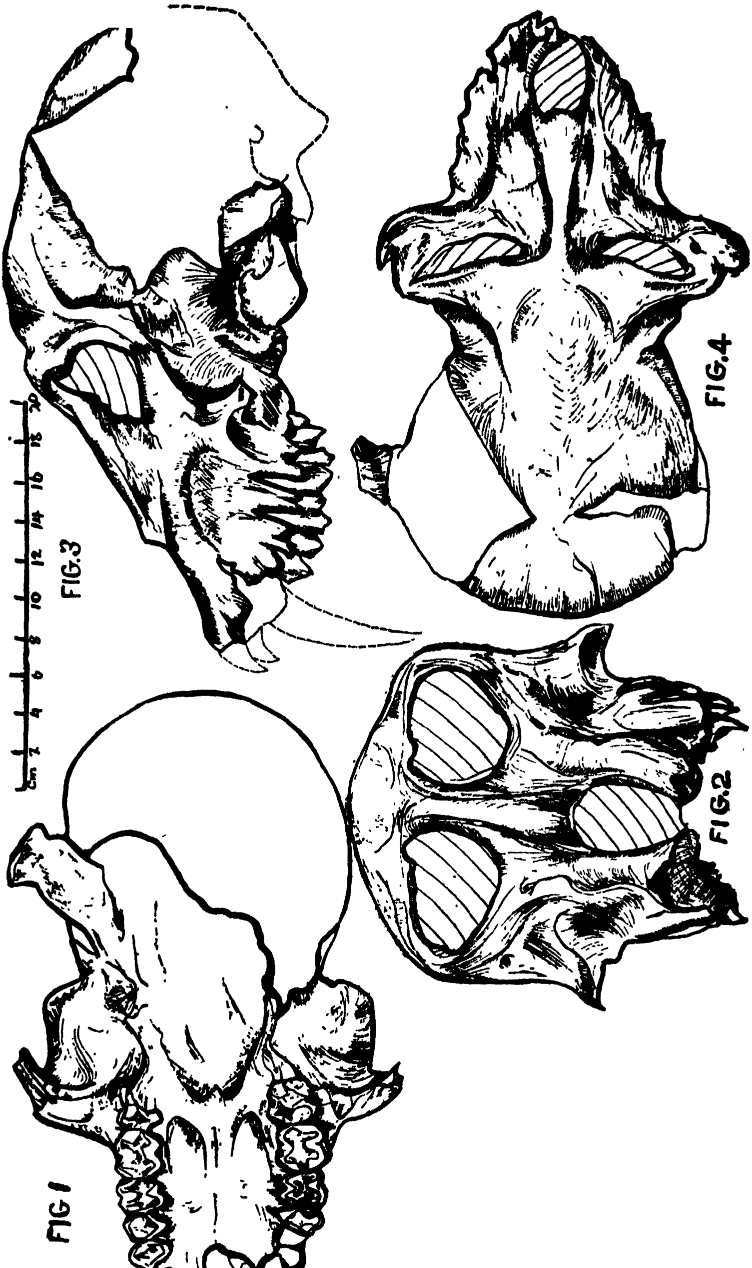
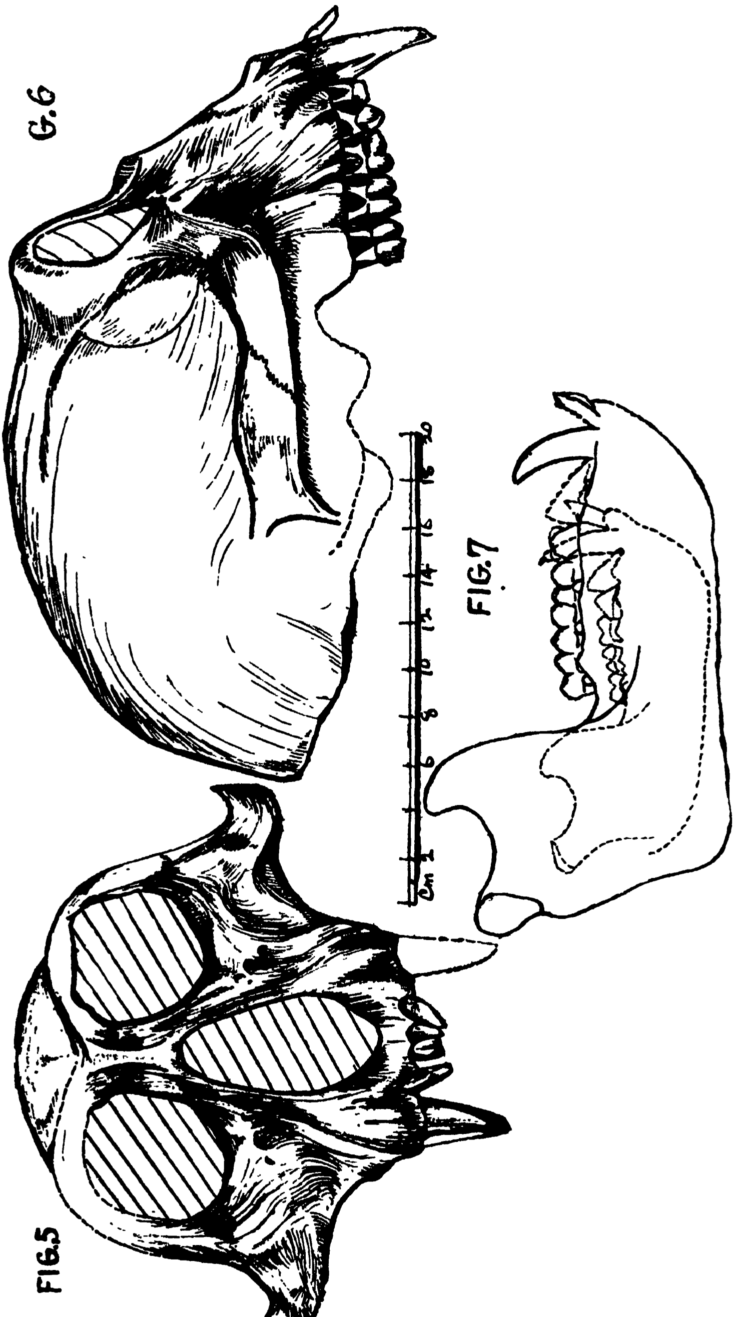


FIG 1

FIG.2

FIG.3

FIG.4


G.6
FIG.7
Cm 2 4 6 8 10 12 14 16 18 20
FIG.5

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FOSSIL MAMMALS FROM THE MAKAPAN VALLEY, POTGIETERSRUST. II. *SUIDAE*

BY

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Read 3rd July, 1946.

Abstract.

At least two extinct genera of Suidae have been recovered from the limestone deposits of the Makapan Valley. One of these belongs to the wart-hog group, but is specifically distinct from all the known fossil South African members of this group. The second is closely related to the existing bush-pig Potamochoerus, but is clearly distinguished from it by possessing a much more hypsodont third molar tooth. Detailed description of these types has been deferred until more extensive material now available has been studied.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 305-307, July, 1947.*

INTESTINAL PARASITES IN NATAL

BY

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Read 1st July, 1946.

During the year 1945 a series of 11,386 specimens of stool from 5,352 cases of suspected amoebiasis were examined at King Edward VIII Hospital, Durban. Of the cases 4,852 were Africans and 500 Indians. The majority of specimens were examined by direct film only, but a proportion (1,148 specimens) were examined in addition by Faust's(1) Zinc Sulphate Flotation technique. The results are given in Table I.

TABLE I.

Case Incidence—Intestinal Parasites, 1945.

PARASITES	AFRICANS		INDIANS		TOTAL	
	No.	per cent	No.	per cent	No.	per cent
E. histolytica	1335	27.51	45	9.00	1380	25.78
E. coli	413	8.51	19	3.8	432	8.07
E. nana	298	6.14	22	4.4	320	5.98
I. Butschlii	63	1.30	9	1.8	72	1.35
G. Lamblia	36	0.74	2	0.4	38	0.71
C. Mesnili	75	1.55	2	0.4	77	1.44
Other flagellates	223	4.60	17	3.4	240	4.48
B. coli	7	0.14	—	—	7	0.13
T. trichiura	1435	29.58	128	25.6	1563	29.20
Strongyloides spp.	81	1.67	41	8.2	122	2.28
Ankylostoma spp.	122	2.51	38	7.6	160	3.00
Oxyuris	4	0.08	1	0.2	5	0.09
Ascaris	1822	37.55	191	38.2	2013	37.61
S. Mansoni	.39	0.80	7	1.4	46	0.86
S. haematobium	2	0.04	—	—	2	0.04
Taenia spp.	189	3.90	6	1.2	196	3.66
H. nana	1	0.02	—	—	1	0.02
No parasites found	1593	32.83	190	38.0	1783	33.31
Total cases examined	4852		500		5352	

For purposes of comparison Table II shows some incidences in other parts of the world.

TABLE II.

Parasites	Natal Africans	Natal Indians	2 New Orleans	3 Syria & Lebanon	4 Indiana	5 Kentucky
E. histolytica	27.51	9.0	8.3	12.9	0.8	5.0
E. coli	8.51	3.8	12.4	31.6	25.6	50.2
E. nana	6.14	4.4	19.6	26.3	12.4	42.3
I. Butschlii	1.30	1.8	0.9	11.47	0.8	11.3
G. Lamblia	0.74	0.4	16.6	10.02	9.7	5.7
C. Mesnili	1.55	0.4	1.6	11.95	0.8	1.0
Other flagellates	4.60	3.4		+++		
Balantidium coli	0.14	—	0.02	—	—	—
T. trichiura	29.58	25.6	9.0	6.07	0.8	7.9
Oxyuris	0.08	0.2	2.4	2.86	5.0	0.4
Strongyloides	1.67	8.2	0.9	1.09	—	3.8
Ankylostoma spp.	2.51	7.6	1.1	0.01	0.4	14.6
A. lumbricoides	37.55	38.2	6.8	31.6	0.8	5.1
S. Mansoni	0.80	1.4	—	—	—	—
S. haematobium	0.04	—	—	—	—	—
Taenia spp.	3.90	1.2	0.14	8.12	—	—
H. nana	0.02	—	0.14	2.52	0.4	2.5

The high relative incidence of E. histolytica in these figures as compared with E. coli (the usual ratio is reversed) is to be related to the fact that a dysenteric population was the source of the specimens. The findings as regards this parasite have been discussed elsewhere.(6)

Entamoeba coli and Endolimax nana are, by comparison with other parts of the world, relatively uncommon. This is strange in view of the high incidence of other parasites with a similar epidemiology. Iodamoeba Butschlii is not a frequent inhabitant of the bowel.

In identifying the flagellates, these were classified only into Giardia, Chilomastix and others. As has been reported elsewhere(7) the incidence of Giardia is low in the African, even in comparison with the local European. A similar state holds with Chilomastix, though other flagellates are frequently found.

Balantidiasis apparently occurs sporadically, our cases always occurring in groups.

Trichuris infestation is common, the local figures being higher than are found anywhere.

Oxyuris infection is probably much more common than is shown in these figures, as the examination of faeces is not likely to reveal evidence of these parasites.

Strongyloidiasis and hookworm infection may be conveniently classified together in view of their similar epidemiology.

The local African is not an agriculturist and is not infested to the same degree as is the Indian market gardener who, in addition, is suspect of using human ordure directly for fertilisation.

The incidence of Ascaris is high and it is probable that the area may be termel an "Ascaris environment".(5) Symptomatology definitely attributable to the larval phases has not been reported locally, but obstruction of the intestinal lumen is not unknown.

Schistosomiasis mansoni, when proved, is generally associated with an intractable diarrhoea. This parasite has not received sufficient attention locally, due perhaps to the facts that diarrhoea is commonly associated locally with amoebiasis, the females do not deposit many ova and these are not always amenable to flotation. S. haematobium, though locally commonly found in urine, is not often observed in the faeces. Once, though not in the present series, we were confronted with a case having S. Mansoni in the urine and S. haematobium in the stool.

Taenia ova are commonly found in the African and, when segments have been available, they have always been of *T. saginata.* The six cases of Taeniasis found in Indians were all seamen from passing ships. It is not likely that mutton eaters would be infected. A similar argument applies to Balantidiasis.

Only a single case of Hymenolepis nana was noted. Isolated cases have also been observed in Europeans locally.

SUMMARY.

The incidence of intestinal parasites in the Africans and Indians in Durban is given, and points in their epidemiology discussed.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 308-311, July, 1947.*

IMPROVEMENTS IN SOME ROUTINE HISTOLOGICAL STAINS

BY

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1. *Haematoxylin and Eosin.*

The majority of haematoxylin and eosin techniques involve differentiation of the haematoxylin with acid alcohol. This differentiation is erratic, and the final results will depend on the skill and experience of the technician.

Recently Ziegler (1944) introduced a modified method of routine staining with haematoxylin, which he claims eliminates this disadvantage and gives consistently good results. In this technique the slides are brought down to water and then treated as follows:

1. 8 seconds in physiological saline,
2. 5 minutes in Delafield's or Harris' haematoxylin,
3. 8 seconds in saline,
4. 4 seconds in 2% phosphotungstic acid in saline,
5. 8 seconds in saline,
6. 8 seconds in 2% sodium citrate in saline,
7. 8 seconds in saline,
8. 2 minutes in eosin.

The slides are then taken through 90 per cent. and absolute alcohol into xylol and mounted in balsam. Ziegler states that the technique is only successful with 10 per cent. formol-fixed tissues and with haematoxylin solutions containing no acid. Since much of the material in this laboratory is treated with fixatives other than formalin, e.g. Regaud, Bouin, it was thought desirable to adapt Ziegler's technique to such material.

This was accomplished by omitting a few of the washes in saline between various procedures, and by increasing the time in sodium citrate from 8 seconds as advocated by Ziegler, to 1-2 minutes. This modification also permitted the use of Ehrlich's acid haematoxylin, the stain most favoured in this laboratory, instead of Delafield's or Harris' haematoxylin, as recommended by Ziegler.

The technique now used is as follows:

The slides are brought down to water and treated in the following way:

1. 5 minutes in Ehrlich's haematoxylin,
2. Rinse in saline,
3. 15 seconds in 2% phosphotungstic acid in saline,
4. Rinse in saline,
5. 1 to 2 minutes in 2% sodium citrate in saline.

After washing in water, the slides are stained with eosin for one minute, washed in water again, dehydrated in alcohol, cleared in xylol and mounted.

2. *A Counterstain for the Weigert's Elastic Stain.*

The modified Ziegler's technique has proved extremely useful in this laboratory, particularly as a satisfactory counterstain for the Weigert's resorcin-crystal violet stain for elastic fibres (Gatenby and Painter, 1937).

In the past it has not been possible to apply a satisfactory counterstain to sections prepared by Weigert's technique. Elastic preparations were either counterstained with red basic aniline dyes such as safranin, or with the von Gieson's technique for connective tissue. Neither of these procedures gives a clear differentiation between nuclei and cytoplasm and, in addition, the picric acid used in the latter technique removes the stain from the delicate elastic fibres. The best counterstain for routine work would be the one involving the use of haematoxylin and eosin. This latter technique, as previously used, involved differentiation in acid alcohol, which removes the stain from the elastic fibres.

The modification of Ziegler's technique reported in this paper, gives excellent results as a counterstain for elastic preparations, as the phosphotungstic acid used as a differentiating reagent for the haematoxylin, does not affect the delicate elastic fibres. Slides are first stained with Weigert's resorcin-crystal violet, differentiated in 90 per cent. alcohol, and then treated with the modified haematoxylin and eosin technique. In this way, the elastic fibres, the nuclei of cells and the cytoplasm, as well as the red blood cells are selectively stained.

3. *Giemsa Stain.*

The Giemsa stain when applied to paraffin sections is not only useful for tissues such as spleen and lymph glands, but also gives excellent results with glandular tissues fixed in Zenker formol solutions.

The technique was used on the human stomach in order to obtain clear differentiation between the parietal, surface cells and serozymogen cells. In order to obtain clear pictures, standard books on histological techniques (Gatenby and Painter, 1937)

advocate differentiation in 95 per cent. alcohol, but the Azur II colours diffusely all the tissues, including the cells and muscle. This disadvantage was overcome by differentiating the stained sections in a 0.5 per cent. solution of glacial acetic acid in absolute alcohol.

The material is fixed in Zenker formol solution and paraffin sections are cut at 4 microns, and mounted in the usual way. Slides are taken down to water and are stained for 5-12 hours in the following dilute solution of the Giemsa stain:

1 part Giemsa stain, and 100 parts distilled water.

The slides are then dipped in 0.5 per cent. acetic alcohol, washed in clean absolute alcohol, cleared in xylol and mounted in clarite.

This modification eliminated the diffuse staining effect of Azur II mentioned above. The muscle cytoplasm was clearly differentiated and the various types of cells in the glands were selectively stained. The results were brilliant, and sections prepared in this way are used for teaching purposes.

4. *Wilder's Reticulum Stain.*

Experience with the Wilder's reticular stain in this laboratory, has shown that while the coarser fibres are well stained, the finer ones are not at all demonstrated. In addition, the technique is difficult to control; even in the same series of sections the results may be inconstant.

In a technique used by Gordon and Sweets (1936) for the staining of reticular fibres, mention was made of the value of acidified potassium permanganate as an oxidising agent.

By using this acidified solution of potassium permanganate with the Wilder's technique, excellent results were obtained with a wide variety of tissues. All the finest fibres were impregnated and, in addition, it was found that very little toning in gold chloride was necessary. This has the added advantage of eliminating overtoning and the possibility of removing the stain from the very delicate fibres.

The technique now used is as follows: Fixation is carried out in Zenker for about 3-4 hours and paraffin sections cut at 6 microns. The sections are brought down to water and the subsequent treatment is as follows:

1. 0.5% solution of sulphuric acid in a 2% solution of potassium permanganate, for 3 minutes,
2. Wash and bleach in 5% oxalic acid for 1 minute,
3. Wash in water and rinse in distilled water,
4. 2 seconds in 1% uranium nitrate,
5. Rinse in distilled water.

The subsequent procedures of impregnation with silver nitrate, toning, etc., are carried out as described by Gatenby and Painter

(1937). With this technique the finest fibres in the spleen and other tissues were consistently displayed.

ACKNOWLEDGMENTS.

I wish to acknowledge my indebtedness to Drs. Theodore and Joseph Gillman and Mr. S. Brenner for the useful suggestions they made which led to the perfection of the above methods.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 312-319, July, 1947.*

THE CHARACTERIZATION OF THE SPERMATOGONIAL CHROMOSOMES OF THE ALBINO RAT (*RATTUS NORVEGICUS ALBINUS*)

BY

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INTRODUCTION.

The spermatogonia of the albino rat have been an object of frequent studies in the past. Much of the earlier work was devoted to the determination of the chromosomal number of this species. Pincus (1927) has summarised the counts made prior to that time. It is evident from his table that considerable discrepancies were recorded, owing no doubt to the poor fixation obtained under the older technique. In 1918, Allen came close to the accepted figure when he reported 37 chromosomes in the spermatogonia. He was able to identify eighteen pairs of homologous autosomes, and a sex-determining X-chromosome. Rauh (1925) quoted by Minouchi, counted seven equatorial plates of the male rat and found 40 chromosomes in six instances, and 41 in the seventh.

Painter (1926) first reported the accepted figure of 42 chromosomes in spermatogonia of albino rats. This count was confirmed by his study of somatic mitoses in amniotic cells of male and female embryo rats. He found, too, that sex in the rat is governed by an XX-XY mechanism, the male being the heterogametic sex. The diploid number of chromosomes was verified by investigators in the United States (Pincus, 1927; Swezy, 1927), in Japan (Minouchi, 1928) and in England (Bryden, 1932; Koller and Darlington, 1934).

While much attention was devoted to the chromosomal configurations at meiosis in the rat, little attempt was made to describe or characterize the individual members of the mitotic chromosomal complement. Pincus, Painter and Bryden arranged the mitotic metaphase chromosomes in serial alignment. They paired forty of the chromosomes on the basis of general similarity in size and appearance. The remaining two elements constituted a heteromorphic pair, which these workers regarded as the X-Y pair. However, as each member of this heteromorphic pair fell within a group of chromosomes approximately equal in size, there could be no certainty that the true X and Y chromosomes had been identified as such.

The only chromosomal measurements which have been provided are those of Koller and Darlington. According to these workers, the chromosomes of the largest pair are about 3.6μ in length, while the rest of the complement ranges in length down to 0.6μ.

It is manifest from a brief survey of the literature that the meiotic chromosomes of the rat, and particularly the heteromorphic pair have been thoroughly studied, whereas the mitotic chromosomes have been largely neglected. The present study was designed to remedy this deficiency by providing as complete a characterization of the mitotic chromosomes as is possible in a species with so large a complement.

Material and Methods.

The testes of four young albino rats (*Rattus norvegicus albinus*) were removed under ether anaesthesia. One testis from each animal was fixed in Bouin's solution for 24 hours, dehydrated, cleared and embedded in parafin wax. Sections were cut at 7μ and stained with Newton's crystal violet and the Feulgen reagent. While the sectioned material was not favourable in most instances for detailed measurements of metaphase chromosomes, it nevertheless provided useful information about the association of metaphase plates with other cell types in the same tubule. Squash preparations were made from the other testes, after fixation in 25 per cent. acetic alcohol. These were re-stained with Ehrlich's acid haematoxylin or Heidenhain's iron haematoxylin, according to the method recommended by Brenner (1946). The squash preparations were used for making detailed observations including measurements.

Measurements made directly on the preparations with an ocular micrometer can introduce a significant error. This was obviated by measuring the lengths on camera lucida drawings, which were made at a magnification of 2,550 x (immersion objective 97x and eyepiece 15x). The final length was corrected to the first decimal place; any errors of measurement or of drawing became insignificant when divided by the magnification. The difficulties of overlap or foreshortening were eliminated by focussing with the fine adjustment. Where this was not possible the plates were rejected.

Observations.

1. *Chromosomal Number.*—In twelve spermatogonial metaphase and prometaphase plates in squash preparations, the chromosomal number was consistently found to be forty-two. The validity of this number received verification from the 21 diads observed in primary spermatocyte nuclei. The observation served as additional confirmation of the number reached by previous workers on sectioned material.

2. *Chromosomal Shape.*—Centric constrictions are most easily observed in late prophase or prometaphase nuclei when they appear as short achromatic gaps in the chromosomes. For reasons to be mentioned later, it was necessary to establish the shape at metaphase as well as at prometaphase.

In prometaphase plates (Figs. 1, 12) twenty-eight chromosomes possessed sub-terminal constrictions, and the remainder median constrictions. These results are not entirely in accordance with the observations of Koller and Darlington as depicted in their illustration of a mitotic metaphase plate. Their plate portrayed 27 elements with sub-terminal constrictions and 15 with median constrictions. The disparity may be due to the confusion of a sub-median for a sub-terminal constriction, or vice versa, in one of the smaller elements.

Two types of sub-terminal constriction were observed. In one, the achromatic gap representing the centric constriction was situated some distance from the end of the chromosome. The distance ranged from about 1/10 of their length in the larger chromosomes to about 1/5 of their length in the medium-sized elements. The second type of sub-terminal constriction was so close to the end of the chromosome that only a small chromatic granule was visible distal to the constriction. It is probably the same or a similar structure which Minouchi named the "polar granule". Several chromosomes had sub-terminal constrictions intermediate in position between these two types.

The possession of median constrictions was confined to the smaller elements. Hence it was not possible to measure the two limbs on either side of each constriction with accuracy, nor to determine whether any of the so-called median constrictions were actually sub-median in position.

At metaphase, it was impossible to observe constrictions in every chromosome (Fig. 13). The most favourable plates contained fourteen elements with median constrictions. Such a chromosome appeared as two small granules lying side by side and separated by a thin region corresponding to the centric constriction. Of the rest of the complement, a variable number contained obviously sub-terminal constrictions, while the remainder were uniformly rodlike. In no instance was a centromeric granule observed in the indented portion of the chromosome.

It is apparent from these findings that different conclusions would have been drawn if only prometaphase or only metaphase plates had been examined. A study of metaphase plates alone would have led to the conclusion that a certain number of chromosomes possessed no centric constrictions and were terminally-attaching or telomitic; whereas, from a study of both stages, it is possible to say that the rod-like appearance of

some elements resulted from the difficulty of detecting terminal granules in chromosomes with immediately sub-terminal constrictions.

3. *Chromosomal Length.*—The chromosomal length is the most variable of the features mentioned so far. In spermatogonial chromosomes of the albino rat, Pincus and Minouchi both found variation in length. However, they did not attempt to give exact mathematical expression to the size variation for the whole complement.

The size range was assessed for the chromosomes of the albino rat. In this description, " size-range " refers to the varying lengths of one chromosome recognisable in different metaphase plates. For this purpose, the lengths of the chromosomes in eight spermatogonial plates from the same tubule were determined. The results are represented diagrammatically in Figs. 2-9. The chromosomes are arranged in order of length, but no effort has been made to pair them off in this diagram, nor to distinguish the heteromorphic pair. The lengths at any one position in the linear series cannot be assumed to represent the same chromosome in different plates, unless that chromosome has been accurately characterized on criteria other than size. This assumption cannot be made because a chromosome may become slightly more contracted in one plate than in another, thus altering its position in the series. The composite graph (Fig. 10) indicates the size range in any part of the series. In addition, the broken lines can be regarded as a measure of the size range of a particular chromosome only when this element occupies a constant position in the series. The five largest and four smallest chromosomes fall into this group (Fig. 11).

Simpson (1941) has pointed out that it cannot be assumed that the observed range of variation represents the true or population range. The latter can only be determined by an examination of every spermatogonial plate in every existing albino rat—a highly impracticable procedure. The spermatogonial plates examined in the present investigation represent only a sample of the possible total. Thus it is improbable that this sample contains the true largest and smallest lengths for any one chromosome. Nevertheless, it would not be expected that the true size range is much greater than the observed range, owing to the relative constancy in length of the spermatogonial chromosomes.

DISCUSSION.

At metaphase, it has been shown, not all the chromosomes appear to have centric constrictions (Fig. 12). Hence, if it is desired to pair off the metaphase chromosomes accurately, it is essential to establish a correspondence between the shapes observable at prometaphase and the lengths measured at metaphase. Even if this could be effected completely, the two

characters of size and position of centric constriction do not provide sufficient information to pair off all the chromosomes. Accordingly, a third feature was necessary, and this was found in the general appearance of the chromosomes. By general appearance of the chromosomes is meant such features as thickness, evenness of contour, degree of tapering between the end of the chromosome and the centric constriction.

By the combined use of these three features, the chromosomes of the rat were characterized as completely as possible.

The four largest chromosomes possessed sub-terminal constrictions and fell into two pairs on the basis of size. Fig. 11 represents the maximum and minimum observed lengths of these two pairs, as well as of the fifth element, the two smallest pairs and the presumptive Y-chromosome. Where there are differences in length between two members of a pair, there can be no certainty that, in different plates, the same element will invariably be the larger. Hence the size range for one member of the longest pair may be taken as the mean range for both members. This is depicted by the horizontal broken line in Fig. 11. The same applies to the second pair.

The fifth largest chromosome could not be mated. It has a sub-terminal constriction and its range (2.8—3.1μ) is smaller than the ranges for the other large chromosomes. It is presumed that this fifth element is the larger member of the heteromorphic pair found by earlier workers, and it may be called the presumptive X-chromosome. The size range reported corresponds well with Koller and Darlington's figure of 2.9μ as the length of the larger of two chromosomes sometimes found lying off the metaphase plate.

The four smallest chromosomes consist of a larger pair with median constrictions and a smaller pair with immediately sub-terminal constrictions. In the latter pair, the terminal granule is not detectable at metaphase, the two chromosomes appearing oval. The size ranges of the smaller chromosomes have a small absolute value. In addition, relative to their chromosomal lengths, the ranges are smaller than those of the longer chromosomes.

Between these two well-defined groups of chromosomes are ten larger pairs with sub-terminal constrictions, six smaller pairs with median constrictions, and an unmatched chromosome. The intermediate sixteen pairs of chromosomes could not be characterized individually, but only as groups. The members of the groups exhibit a gradation of size and shape, so that it is impossible to distinguish the same pair within two plates with complete certainty.

The smaller unmatched element is the presumptive Y-chromosome. It is the smallest chromosome with a sub-terminal constriction apart from the pair already described. It

is recognisable at metaphase when its length in various plates was found to be 1.2—1.3μ. The length of Koller and Darlington's presumptive Y-chromosome was 1.1μ. In six plates it occupied position 34 in the linear series, while in three others it was 28, 32 and 36. This illustrates the earlier statement that one chromosome may lie in different positions in the linear series in several plates.

Table 1 summarises the final characterization. The size ranges quoted for any group represent the range between the extreme lengths of the smallest and largest members of the group.

TABLE 1.

Chromosome or Group	Length	Position of centric constriction
Pair 1	3.6—4.4μ	Sub-terminal
Pair 2	2.9—3.9μ	Sub-terminal
Presumptive X	2.8—3.1μ	Sub-terminal
Pairs 3—12	1.4—3.1μ	Sub-terminal
Pairs 13—16	1.2—2.9μ	Median
Presumptive Y	1.2—1.3μ	Sub-terminal
Pairs 17—19	0.8—1.3μ	Median
Pair 20	0.8—0.9μ	Sub-terminal

The type-graph (Fig. 11) is an attempt to represent these results graphically. If possible variations in the linear order are borne in mind, this graph may be used as the type-graph for the species, in comparisons with the chromosomal complements of closely related species.

SUMMARY.

1. Studies have been made on the mitotic chromosomes of the albino rat to characterize them as accurately as possible.

2. The diploid chromosome number has been found to be forty-two in dividing spermatogonia.

3. The complement has been characterized on the basis of chromosome length, position of centric constrictions, and general appearance. In this way, it has been established that the complement consists of thirteen pairs with sub-terminal constrictions, seven pairs with median constrictions, and a heteromorphic pair, the presumptive X- and Y-chromosomes.

4. It has been found that mitotic chromosomal length has a range of values for any chromosome pair in the rat, and is not a constant single value. Size ranges have been established for the complement.

ACKNOWLEDGEMENTS.

I wish to thank Professor R. A. Dart for the research facilities provided in the Department of Anatomy. I take this opportunity to express my deep gratitude to Dr. J. Gillman for his sustained advice and searching criticisms in the preparation of this paper. To Mr. S. Brenner I am much indebted for his assistance in the initiation of this research and his encouragement during its progress. Finally, I wish to acknowledge the valuable assistance of Mr. D. S. Dry with the microphotography.

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ILLUSTRATIONS.

Fig. 1.—Linear alignment of the chromosomes of a mitotic prometaphase plate. Lengths in μ. In this figure the positions of the centric constrictions are indicated.

Figs. 2-9.—Linear alignments of the chromosomes of eight mitotic metaphase plates.

Note that the chromosomes are not paired off, nor is the heteromorphic pair indicated.

Fig. 10.—Composite Graph of size range and position of centric constrictions in the chromosomal complement of the Albino Rat.

Fig. 11.—Size ranges of four largest and four smallest chromosomes, and of Presumptive X- and Y-Chromosomes.

Fig. 12*b*.—Drawing from a photomicrograph of mitotic prometaphase plate. Acetic orcein squash preparation re-stained with Ehrich's Haematoxylin x4000.

Fig. 13*b*.—Drawing from a photomicrograph of mitotic metaphase plate. Acetic orcein squash preparation re-stained with Heidenhain's Haematoxylin x4000.

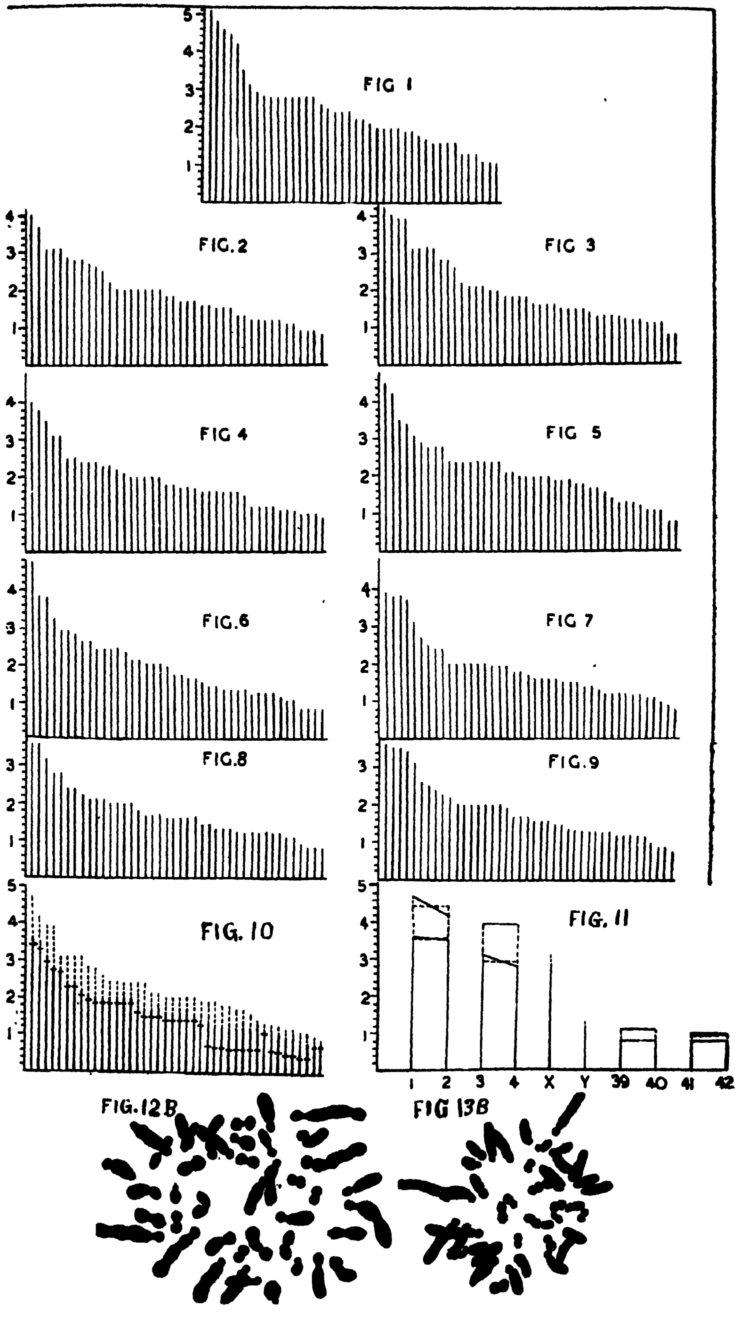
FIG 1
FIG.2
FIG 3
FIG 4
FIG 5
FIG.6
FIG 7
FIG.8
FIG.9
FIG. 10
FIG. 11
1 2 3 4 X Y 39 40 41 42
FIG.12B
FIG 13B

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 320-323, July, 1947.*

THE NON-SPECIFICITY OF THE NADI REACTION FOR THE CYTOCHROME OXIDASE-CYTOCHROME C SYSTEM

BY

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Read 2nd July, 1946.

The need for establishing specific tests for the various chemical constituents of cells is very urgent. Only when these are available will it become possible to interpret the complexities of cell structure. There are only a limited number of histochemical techniques which can be regarded as exhibiting any degree of specificity. Significant examples are the Feulgen reaction for desoxyribonucleic acid and the Gomori test for phosphatase.

Many investigators are of the opinion that the Nadi reaction is specifically catalysed by an oxidising enzyme, "indophenol oxidase". The work of Keilin (1933) has revealed that this is identical with a cytochrome oxidase-cytochrome-c system.

The main application of the Nadi reaction has been in haematological research, where it is used to distinguish between lymphoid and myeloid series of the blood cells. The latter, it is stated, react positively. In recent years, there has been a further application of the test to a wide variety of tissues, such as choroid plexus (Flexner and Stiehler, 1938), pig foetal kidney (Flexner, 1939), thyroid (Dempsey, 1944), and placenta (Dempsey and Wislocki, 1944). All these investigators claim that a positive Nadi reaction demonstrates the presence of a cytochrome oxidase-c system. Dempsey and Wislocki (1944), base a number of far-reaching conclusions on this alleged specificity of the Nadi reaction. For example, by comparing the data of Weed (1917) on glycogen, and that of Flexner and Stiehler (1938) on the Nadi reaction of the choroid plexus, they show that the disappearance of glycogen in the foetal choroid plexus, is synchronous with a more intense Nadi reaction. Interpreting a positive Nadi reaction as demonstrating the presence of a cytochrome oxidase-c system, they proceed to deduce a causal relation between glycogenolysis and the increase of oxidase activity. This, if true, becomes an important fact. However, it is evident that such an interpretation presupposes a specific catalysis of the Nadi reaction by cytochrome oxidase-cytochrome-c enzyme system.

In the course of a series of investigations conducted in this laboratory on the Nadi reaction, there arose good reason to

suspect that the reaction was not at all specific for the cytochrome system. It was found that the Nadi reaction can also be obtained with intracellular lipoids. The objects of this note are to present briefly the pertinent results of these investigations, and to discuss them in the light of previous literature.

METHODS.

The technique consists of the application of solutions of dimethyl paraphenylenediamine and a-naphthol to sections or teased pieces of fresh unfixed tissues. A positive reaction is demonstrated by the appearance of a blue dye, indophenol blue, in the cells. The reagents were prepared as recommended by Nicolet (1923). The test was performed on 75μ frozen sections of unfixed rat liver. In addition to a standard test, a control was run which was identical with the former, except that KCN was added to the reagents until a final concentration of 10^{-3} M Cyanide was present. All the preparations were studied immediately after the completion of the test, as the indophenol blue may fade in a few hours.

OBSERVATIONS.

The cytoplasm of the liver cells stained diffusely blue, while the nucleus was unaffected, appearing as a clear vacuole. Numerous globules in the Kupffer cells stained an intense purple colour, as did the few positive granules in the hepatic cell. There was no detectable difference between the cyanide controls and the standard tests.

The distribution and size of the Nadi-positive globules and granules correspond closely to the localization of fat as demonstrated by staining the same series of sections with Sharlach R. Moreover, the diffuse reaction of the cytoplasm with the Nadi reagents possessed a counterpart in a diffuse sudanophilia of the cytoplasm.

COMMENT.

It is evident then, that the Nadi reaction is not specific for the cytochrome system. If it did show specificity, then the cyanide control should have been negative. No such inhibition was observed.

A second important point is also immediately clear. The localization of indophenol blue in the cell at the completion of the reaction corresponds with the distribution of fat as detected with Sharlach R. In other words, the Nadi reagents can stain lipoidal materials in the cell.

A survey of the literature provides ample evidence in support of this conclusion. Solutions of indophenol blue have been applied as fat stains (Conn, 1940). Navez (1938), who also doubted the specificity of the Nadi reaction, extracted a fat from Arbacia eggs which reacts positively with the reagents. Finally,

Hollande (1924) obtained the same results by staining with solutions of indophenol blue as with the Nadi reagents. This indicates that in addition to the catalysing centre in the cell, there are other substances which have an affinity for indophenol blue. The indophenol blue could be formed from the Nadi reagents by an auto-oxidation process. The dye then acts as a fat stain, in the same way as Sharlach R.

The Nadi reaction as applied to the granulocytes requires further analysis. Fixation is carried out in a highly concentrated mixture of alcohol and formol (Nicolet, 1923). Although this fixation does not affect the Nadi reaction, it is known that cytochrome oxidase is rapidly destroyed by this type of treatment (Keilin, 1933). In this case, a positive Nadi reaction is obtained in the absence of the cytochrome oxidase system.

Since the blood cells were treated with alcoholic fixative, it is evident that the Nadi reaction cannot be staining the same type of fat as in the liver cells. De Bruyn (1937) has found that alcohol-extracted granulocytes contain no sudanophil material. However, when such preparations are placed in solutions of a-naphthol or various other phenols, sudan-stainable fat appears in the cell. In the case of the Nadi reaction as performed on the formol-alcohol fixed granulocytes the a-naphthol therefore unmasks fat. This is stained by the indophenol blue, probably released by auto-oxidation. The final result is a positive Nadi reaction.

In the light of the present investigation it is evident that Dempsey and Wislocki's (1944) interpretation of their results is untenable. While the statement that glycogenolysis is associated with the increase in the intensity and distribution of a Nadi reaction is perfectly legitimate, the latter can no longer be interpreted as a specific increase in oxidase activity. Instead, a positive Nadi reaction may indicate the presence of lipoid, either "masked" or immediately stainable. The fact that glycogenolysis and fat formation are closely linked processes is to-day well established.

The results of the present study discount the view that the Nadi reaction is specific for the cytochrome oxidase-cytochrome-c system. The Nadi reaction also stains fat, either free as such within the cell or unmasked simultaneously by the -naphthol.

This experience with the Nadi reaction indicates a need for a critical re-examination of other so-called specific histochemical tests in use to-day. Blind acceptance of the specificity of these reactions may lead to interpretations unjustified by the facts.

ACKNOWLEDGEMENTS.

I wish to express my thanks to Professor R. A. Dart for providing the facilities for this investigation in the Department of Anatomy. I am indebted to Dr. Joseph Gillman for constant encouragement and valuable criticism.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, p. 324, July, 1947.*

DIE INVLOED VAN DIE BYVOEDING VAN MAKLIK TOEGANGLIKE VOEDINGSBESTANDDELE OP DIE VERTEERBAARHEID VIR SKAPE VAN DIE SELLULOSE IN 'N SWAK VELDHOOI

DEUR

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Gelees 3 Julie 1946.

UITTREKSEL.

Daar skyn min twyfel daaroor te wees dat beskikbare energie die primêre tekort van die droë winterweidings in die somerreënvalstreek van Suid Afrika is. Nagenoeg 90 persent van die organiese materiaal van hierdie tiepe weiding bestaan uit sellulose, hemisellulose en lignien; stowwe wat dus beskou moet word as bykans die enigste bron van potensiële voedingsenergie. Dit is bekend dat simbiotiese mikroorganismes in die rumen van herkouers verantwoordelik is vir die vertering van die sellulose en hemisellulose en dat lignien remmend op daardie vertering werk. Daar is ook rede om aan te neem dat die omvang van hierdie polisakkariedvertering beïnvloed kan word deur 'n tekort aan 'n nutriënt soos stikstof wat nodig is vir die groei van die organismes. Met die doel om na te gaan of sodanige tekort in ons droë winterweidings aanwesig is, is die invloed van die byvoeding van verskillende hoeveelhede van 'n supplement bestaande uit stysel, kaseïen, brouersgis en 'n volledige mineraalmengsel, met of sonder 'n verdere byvoeding van groenvoer, op die verteerbaarheid van die sellulose in 'n grashooi, bevattende slegs 2.2 persent ru-eiwit, in 'n reeks verteringsproewe met skape vasgestel. Dit het geblyk dat:

(1) Die vermoë van skape om sellulose te verteer, verswak word indien hul vir 'n tyd op die basiese rantsoen van veldhooi alleen gehou word;

(2) Daelikse byvoedings van 20, 50, en 85 gram van die konsentraat per skaap, nie die verteerbaarheid van die sellulose in die basiese rantsoen verbeter net nie, maar dat die laasgenoemde twee byvoedings enige verswakking in die selluloseverteringsvermoë verhinder het;

(3) Die hoogste byvoeding van konsentraat, 170 gram per skaap per dag, die energie tekort van die basiese rantsoen vergoed, maar die verteerbaarheid van die sellulose verminder het;

(4) Die vermoë om sellulose te verteer wat volgens (1) en (3) hierbo tydelik verswak is, deur 'n bykomende supplement van groenvoer herstel is.

Die volledige verslaag sal in die *Onderstepoort Joernal* verskyn.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 325-326, July, 1947.*

AN ARSENIC-RESISTANT TICK AND ITS CONTROL WITH "GAMMEXANE" DIPS

BY

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Read 2nd July, 1946.

ABSTRACT.

During the past thirty years at least seven species of injurious arthropods are known to have evolved strains which are more difficult to kill with recognised chemical insecticides than are the normal populations of these pests.

In 1939 it was reported from the East London area that farmers were experiencing difficulty in controlling the one host blue tick, *Boophilus decoloratus* (Koch), by regular weekly dipping of cattle in the recognised 7-day strength arsenical wash. Field observations confirmed this, but also demonstrated that other species of ticks were controlled by dipping in arsenic.

Owing to the cumbersome nature of any experiments involving the insecticidal treatment of ticks *in situ*, a technique for treating ticks in the laboratory was developed. This technique has been put to an exhaustive test and some 15,000 adult female blue ticks have been subjected to *in vitro* treatments with remarkably consistent results.

Experiments suggested that arsenic killed ticks by contact. By using the technique described it was possible to furnish proof that an arsenic-resistant strain of *B. decoloratus* (Koch) did exist in South Africa. It would seem that when once the arsenic-resistant tick has established itself on any farm, the continued dipping of cattle in arsenical washes, results in an unintentional selection of those varieties within the tick population which are resistant to arsenic. Continued dippings in arsenic would thus aggravate the position. Some insecticide other than arsenic should be used to combat the arsenic-resistant strain of *B. decoloratus* (Koch).

Small supplies of "Gammexane", the name given to the biologically active gamma isomer of hexachlorocyclohexane, reached us in December, 1944, and this new insecticide was shown to have remarkable tick killing properties. Approximately 0.005 per cent. "Gammexane" was the highest concentration necessary to inhibit egg laying by adult female arsenic-resistant ticks.

Oil base preparations and water suspensions of "Gammexane" were twenty times more toxic to ticks than were dust preparations.

By subjecting adult female blue ticks to *in vitro* tests it was possible rapidly to select the most effective preparations from among the many "Gammexane" dips prepared by the Research and Development Department of African Explosives and Chemical Industries, Ltd. Laboratory tests indicated the necessary dilutions at which "Gammexane" dips were to be used in dipping tanks, and predictions made in the laboratory were amply confirmed by large scale field trials. Chemical tests cannot as yet differentiate between the active and inactive isomers of hexachlorocyclohexane, so biological tests were a necessary check on chemical analyses of samples of dip wash. "Gammexane" was shown to be much more toxic than DDT to adult female blue ticks.

When cattle were sprayed with dips containing about fifty parts per million "Gammexane", ecto-parasites consisting of males, females, nymphs and larvae of the blue tick, and lice, started falling off the animals half an hour after spraying. Adult male blue ticks appeared to be very susceptible to "Gammexane" dips. *Ixodes pilosus* (Koch), the sheep paralysis tick, seemed to be resistant to "Gammexane" in the form used.

The spraying tests had no adverse effect upon cattle, so dipping tanks were filled with dips made to the same formulations as the most successful samples tested in the laboratory. At laboratory recommended dilutions, these dips gave striking control of tick life in the field when cattle were dipped at weekly intervals. Scrapings of ecto-parasites taken at weekly intervals from dipped and undipped control animals gave an accurate estimate of the degree of control of tick life which took place.

Thousands of cattle have passed through dipping tanks filled with different "Gammexane" washes, and the animals have suffered no ill effects.

The full text of the paper, of which the above is an abstract, will appear in the *Bulletin of Entomological Research.*

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 327-330, July, 1947.*

A PRELIMINARY REPORT ON THE HISTOLOGICAL MODIFICATIONS IN THE ADRENAL CORTEX OF RATS SUBJECTED TO COLD

BY

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Read 3rd July, 1946.

INTRODUCTION.

The behaviour of the lipoids of the adrenal cortex of the rat in response to cold has not been satisfactorily resolved. Without reference to the time factor there would appear to be no unanimity of opinion as to whether the lipoids are increased or diminished.

Examination of the literature reveals that in the performance of experiments designed to elicit the reactivity of the adrenal cortex in respect of lipoids, there has been no uniformity in the time during which the animal has been exposed to cold.

The results of previous investigators are summarized in Table 1.

All are agreed that the lipoids are decreased after 22-24 hours of exposure to cold. Within the first 4 hours Dosne and Dalton (1941) are of the opinion that the lipoid is decreased, while Flexner and Grollman (1939) found an increase. The different temperatures used by these investigators is one variable factor which might easily have led to such a divergence of opinion. However, it will be the purpose of this paper to show that the behaviour of cortical lipoids in response to cold, is closely related to the time of exposure. Without an appreciation of the significance of the time factor, discrepancies may arise in reports of the reactivity of the adrenal in response to various stimuli, which might easily be attributed to species or temperature differences, or other unknown factors.

MATERIAL AND METHODS.

The 28 male albino rats used in the experiment were of the same weight group (70-100 gms.). All were fed with a good standard diet.

The rats were divided into seven groups. The first group comprising nine animals served as a control, while the remaining six groups, each containing 3-5 rats, were exposed to a temperature of 5-7° C. for the following periods of time:

1 hour, 6 hours, 14 hours, 24 hours, 36 hours and 48 hours. The animals were killed by a sharp blow on the head immediately after cold treatment. The adrenals were promptly removed and both were fixed in 10 per cent. formalin.

The right adrenal was dehydrated and embedded in paraffin wax, while the left was sectioned on the freezing microtome. Sections were cut through the centre of the gland and thus showed both cortex and medulla.

The frozen sections were stained in the routine way with Sudan IV and haematoxylin, for the demonstration of lipoid. The paraffin sections were stained with haematoxylin and eosin, and were studied in conjunction with the frozen sections.

OBSERVATIONS.

The cortex of the control adrenals showed a large amount of sudanophil substance. A slight decrease in cortical lipoid was already evident at the first hour. Further depletion was noted at both the 6 and 14 hour stages. After 24 hours exposure to cold the cortex was almost entirely free of sudanophil substance. The decrease in number of the fat droplets is accompanied by a decrease in their size. As a consequence very fine droplets appeared at the 14 and 24 hours stages.

A substantial return of cortical lipoid was noted at the 36 hour stage. After 48 hours of treatment the amount of sudanophil substance in the cortex was almost identical with that present in the cortex of the control animal. However, the lipoid droplets are smaller at the 48 hour stage than in the control cortex, although the amount of fat in each is approximately the same.

Haematoxylin and eosin sections confirmed the observations made on frozen sections. An initial decrease, and subsequent increase in the size and number of lipoid vacuoles was noted. In addition vacuolar changes were seen in the cytoplasm and in the nucleus.

A very large cytoplasmic vacuole occupying almost the entire cell appeared in the cells of the outer part of the cortex after 24 hours exposure to cold. These vacuoles were seen in both paraffin and frozen sections. Although they are occasionally seen in the control sections, the vacuoles are more numerous in experimental adrenals. Goldberg (personal communication) states that a similar change occurs in the cortex after unilateral adrenalectomy.

A vacuole in the nucleus was also observed in the sections of adrenals after cold treatment. Nuclear vacuoles in the adrenal cortex have been previously reported by Donahue and Parkins (1935) as a response to traumatic shock.

COMMENT.

The table below summarizes the findings of previous investigators on the effect of low temperatures on cortical lipoid.

TABLE 1.

The effect of Temperature on the Lipoid of the Adrenal Cortex.

Author	Temperature of exposure of animals	Time of exposure of animals (hours)	Amount of stainable lipoid
Selye (1936, 1937)	-6°C	24 48	Decreased Increased
Flexner & Grollman (1939)	10°C	1—4 22	Increased Decreased
Bernstein (1941)	23°F (-5°C) 32°F (0°C)	48 120	Decreased Increased
Dosne & Dalton (1941)	-3 to -5°C	1 24 168	Decreased Decreased Decreased

Present experimental findings:

TABLE 2.

Temperature of Exposure	Time of exposure (hours)	Amount of stainable lipoid
5—7°C	1	Slight decrease in lipoid.
	6	More marked lipoid depletion
	14	More marked lipoid depletion
	24	Minimum lipoid present
	36	Substantial return of lipoid
	48	Return to lipoid level of control adrenal

The reactions of the lipoids at the one hour period described here, are in accord with the observations of Dosne and Dalton (1941). The increase reported by Flexner and Grollman (1939) during the first four hours of their experiment is difficult to explain.

It is evident that the behaviour of cortical lipoids in response to cold is intimately dependent upon the time over which the rat is exposed to this type of stimulus. There is at first a decrease already initiated at the first hour and this reduction continues until the 24th hour, thereafter the lipoids return gradually. At

the 48th hour the lipoid present in the cortex is similar to that present in the control.

It follows that provided the stimulus of cold is sufficient to initiate cortical activity, but does not prove fatal to the rat, then irrespective of the level of the temperature, whether —6° C. or +7° C. the adrenal reacts in the same way. However, if this cycle of lipoid reduction and reappearance is not appreciated, and times of exposure to cold are arbitrarily selected, it is clear that discrepancies may arise in experimental results. Thus, if the cortex were examined only at the 24 hour stage a decrease in cortical lipoid would be reported as a response to cold. If, however, it were examined at the 48 hour stage it would appear that no change had occurred, and the existence of a marked lipoid reaction in response to cold would be overlooked.

Reports in the literature indicate that this cycle is continued beyond the 48 hour stage. Thus Bernstein (1941) observed increased lipoid after 120 hours at 0° C., while Dosne and Dalton (1941) found that cortical lipoid is decreased after 168 hours exposure to —3 to —5° C.

While this cycle in the lipoids of the adrenal cortex has been initiated by a cold stimulus, it is likely that other stimuli, adequate to elicit the alarm reaction (Selye, 1936) will result in a similar cyclical decrease and return to normal of the cortical lipoid.

Summary.

The shifts of lipoids in the adrenal cortex represent an expression of the reactivity of this gland. In response to a stimulus such as cold the cortical lipoids become markedly reduced within a specified time. Provided the animal is allowed to survive, the lipoids will reappear in the cortex.

Unless this rhythm is fully appreciated the results of experiments on rat may not always be consistent, especially if animals are examined at intervals when the lipoids are diminished or they have returned to near normal.

Acknowledgements.

I wish to thank Professor R. A. Dart in whose Department this investigation was conducted. The investigation was carried out under the direction of Dr. Joseph Gillman, to whom I am grateful for his advice and assistance. My thanks are due to Miss S. Goldberg for her interest and advice.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIII, pp. 331-343, July, 1947.*

HUMAN CRANIA FROM ROCK-SHELTER BURIALS IN THE MARANDELLAS DISTRICT, SOUTHERN RHODESIA

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With 3 text-figures and 3 tables.

Read 3rd July, 1946.

INTRODUCTION.

The series of crania discussed in this paper is composed of nine specimens, recovered at different times from rock-shelter burials in the neighbourhood of Marandellas, Southern Rhodesia. Skulls M1 to M4 were collected by Mr. M. F. Carver; M5 by Dr. G. F. Berry; M6 and M7 by Mr. C. Maclagan; and M8 and M9 by Mr. W. W. Battiss.

All these burials had been made in walled-up crevices. In the case of M1 to M3, the burials had been disturbed and no relics could be associated definitely with the crania. M4 was recovered *in situ*; the burial was subsequently examined in more detail by Berry (1936). Its most remarkable feature is that the bones have been completely incinerated. This apparently took place after the remains had been skeletonised, yet it seems more probable that the burning was deliberate and not accidental. Berry points out that, in this respect, the find is comparable with those made by Miss Caton-Thompson at Dhlo-Dhlo. With this skeleton white glass beads and remains of reed matting and cotton cloth were found. M5 was recovered *in situ,* together with a wooden platter and a decorated gourd ladle (Berry, 1936). M6 and M7 were found in one grave; as were M8 and M9. With the latter pair a squat, tall-necked pot with impressed decoration at the base of the neck was found.

With the exception of the burnt cranium, M4, all the skulls are completely dried out, weathered and corroded to a variable degree, but not at all fossilised. It is therefore unlikely that any of them are of great antiquity.

This series of crania, like some previously described, shows a mixture of Negro, Bush and Boskop features. The skulls have been classified in three groups on the basis of the proportion of Negro characteristics present.

The first, and larger, group consists of six skulls (M1, M5, M6, M7, M8 and M9), which exhibit a preponderance of Negro characteristics over those of the other two types. Three skulls

of this group (M1, M6 and M8) agree very closely in their essential features. M5 differs in certain respects, suggesting a greater degree of mixture; and M9 displays features of robustness to a greater extent than any of the other skulls. Fundamentally all these crania belong to the same physical type. M7 is very imperfect, but the features which are determinable clearly relate it to the rest of the group.

Unfortunately, it is impossible to determine the sex of these individuals from the skeletal material available. It is therefore just feasible to explain the robust features of M9 by assuming that it is the only male skull present in the collection. On the other hand these robust features may be evidence of a greater proportion of Negro characteristics.

The second group consists of M2 and M3, which show a comparative lack of Negroid characters; but whose features are indicative of homogeneity. M4 might have been included in this, predominantly Bush-Boskop group: but on account of several remarkable features it has been described separately.

In both metrical and non-metrical analysis, considerable use has been made of the criteria formulated by Galloway in his investigation of "The skeletal remains of Mapungubwe" (1937). Comparison has also been made with reports of previous, somewhat similar discoveries.

Skulls M6 and M2 have been chosen for illustration, as the most representative members of their respective groups (Figs. 1 and 2). In addition the remarkable features of M4 merit separate illustration and description (Fig. 3).

Description of Cranial Types.

I. *Predominantly Negro Group.*

Hyperdolichocephaly is a striking attribute of all the members of this group; and further evidence that these individuals belonged to a long-narrow-headed physical type is obtainable from the upper facial indices, all of which indicate leptoprosopy. Altitudinal indices show that, though some of the skulls are orthocephalic, the general tendency is towards a chamaecephalic type (Table Two).

The frontal bossing of these skulls is usually adult, the parietal bossing infantile; and in consequence the cranial form of the skulls of this group is ovoid. M9 differs from the others in possessing a relatively narrower frontal region. M1 and M8 exhibit very slight metopic ridging but this is by no means a marked feature. The post-coronal region is smooth and interparietal grooving is absent.

In lateral norma the glabella is seen to be prominent only in M9. From the nearly vertical forehead the contour passes backwards to a flattened vault whose highest point is 2 to 3 cms.

behind Bregma. The parieto-occipital contour is flattened, and passes downwards to an occiput which tends to be hemispherical; though there is slight evidence of bulging around the maximum occipital point (Fig. 1).

The nuchal plane faces downwards and slightly backwards, and has a sigmoid or flat surface. Slight supra-asterionic flattening is a feature of this group. The parieto-temporal suture is usually an irregular oblique line; which rises very little, if at all, above the level of Pterion.

The mastoid process is of medium size, flattened laterally, and excavated medially by a digastric fossa which is left moderately exposed in most cases. In accordance with the size of the mastoid, the sterno-mastoid ridge is usually not prominent. The mastoid process of M9 differs in that it is well-developed and not laterally flattened. Negroid features are apparent in the supramastoid regions of this group, the supramastoid crest curving only very gently upwards as a backward projection of the line of the zygoma. The tympanic ring is usually thick and strong; and the posterior roots of the zygoma, though not massive, have rounded lateral surfaces.

The temporo-sphenoidal region is elevated into a ridge which is largely due to the markedly hollowed lateral surface of the greater wing of the sphenoid bone. The superior temporal line passes rather sharply backwards to pursue a flattened, though still convex course, circumscribing the inferior frontal eminence which varies greatly in size.

The contour of the frontal region is evenly rounded. The glabella is only prominent in M9; while supraciliary ridges are consistently poorly developed. The external angular process shows slight lateral projection from a supra-orbital triangle which is flat or very slightly excavated. Only one skull, M5, does not show the high rectangular orbits typical of the group. The tranverse axes of the orbits pass obliquely downwards and backwards; while the superior margins are slender and occasionally show slight eversion.

In the nasal region, a relatively narrow interorbital diameter is associated with maxillary processes which face anterolaterally, and arched nasal bones. This arching is particularly marked in M9. The nasal aperture is reminiscent of the pyriform Negro type, though it appears to be more squat. The inferior nasal margin is typically rounded, though in a few specimens there is slight marginal tapering. A well-developed nasal spine is a common finding in these skulls. Metrical examination serves to confirm the classification of this group as distinctly platyrhine, but less so than the typical Negro.

The subnasal region is invariably deep and alveolar corrugation is often present. Marked infra-orbital excavation, as seen in the Negro, is lacking in most of these skulls. The malar

region is devoid of angulation, since the plane of the body of the malar bone is convex and faces antero-laterally.

There is wide variation in the form of the Foramen Magnum. In three of the skulls (M5, M8 and M9) it is almost circular; but the foramen of M9 is considerably larger and has flattened posterior quadrants which meet posteriorly at a right angle. M1 and M6 show more typical Negroid foramina which are elongated and oval. Though the features of the Foramina Magna are manifold, those of the condyles are remarkably constant. The condyles are invariably massive, with rounded and laterally directed articular surfaces; and they encroach slightly upon the anterior quadrants of the Foramen Magnum.

Examination of the inferior aspect of the temporal bone reveals a digastric fossa which is relatively shallow, expanded posteriorly and excavating the medial side of the mastoid process. M9 is atypical in possessing a digastric fossa which is deep, uniform, and grooving the base of the skull. The glenoid fossa, though variable, is usually of medium depth; associated with prominent articular and post-glenoid tubercles.

The Dental Arcade varies in form. M9 presents the most typical Negroid state, the alveolar margin being an elongated "u" with divergent arms; while in M5 and M6 the margin is horseshoe shaped, with an anterior taper. The hard palates are universally deep, slightly rugose, with shelving at the expense of the anterior one-third. No prominent torus was found on the palates.

These skulls never exhibit the marked prognathism which typifies the Negro: the upper face is characteristically orthognathous, though subnasal prognathism is present to a varying degree.

The capacities of the crania are less than those of an average Negro group: M9, however, is sufficiently large to be placed near the upper limit of the Negro range. In assessing the significance of these variations the question of sex must, however, be taken into account (Table One).

II. *Predominantly Bush-Boskop Group.*

This group includes skulls M2 and M3, both of which are represented by little more than the complete calvaria. The available evidence is, however, sufficient to enable one to place them in a group distinct from the previous one.

Cranial indices reveal moderate dolichocephaly, associated with a cranial form which is chamae-ovoid in M3, but chamae-ellipsoid in M2. Bossing in the frontal regions of both skulls is infantile. The profile of the frontal region is distinctive in that the forehead is vertical and tends to overhang the

orbits (Fig. 2). Although the Glabella is not prominent, a shallow ophryonic groove is present.

From the vertical forehead, the contour in Norma Lateralis passes sharply but evenly backwards to a low and flattened vault, whose highest point is situated behind Bregma. Post-coronal and slight supra-asterionic flattening are present. Both skulls are characterised by a shallow post-coronal groove, but this does not invade the midline. Receptacula cerebelli are not prominent on the flattened nuchal plane, which faces more downwards than backwards. Projection of the region around the maximum occipital point produces a somewhat angular and uneven parieto-occipital contour (Fig. 2).

The parieto-temporal suture rises very slightly above the level of Pterion, the posterior limb being low, irregular and oblique. The mastoid process of M2 is small and laterally flattened, leaving the digastric fossa considerably exposed; but the common association of a diminutive mastoid process with a prominent sterno-mastoid ridge is not apparent in this specimen. The supra-mastoid region in this group displays very typical Boskopoid features; the crest being prominent and curving sharply upwards from the supra-auricular point. The supra-mastoid groove is well marked. The tympanic ring in M2 is foetal or Bushmanoid in type.

M2, the only skull in which the temporo-sphenoidal region is intact, displays a small mons temporo-sphenoidale, but inferior frontal eminences are prominent in both skulls.

An examination of the frontal bones shows the absence of supraciliary ridges, and the presence of slight frontal peaking in M2. This skull is further distinguished by a metopic suture which traverses the entire frontal bone. In M2 an unexcavated lateral supra-orbital triangle is continuous with an external angular process which faces more laterally than downwards. Unfortunately no evidence is available concerning the orbits of these skulls.

Cranial capacity could only be measured in M2, and was found to be considerably less than that of the average Negro (Table One). Since this individual was of undetermined sex and apparently sub-adult, the diminutive cranium cannot be taken as characteristic of this physical type.

III. *Skull M4.*

In addition to having been burnt, this skull exhibits several features which distinguish it from the predominantly Bush-Boskopoid group, to which it appears to be related. The skull has been reconstructed from fragments which represent most of the calvarium and the zygomatic and maxillary bones.

The cephalic index reveals a greater degree of dolichocephaly than is present in the Bush-Boskop group. The frontal bone

shows a slight metopic ridge. In Norma Lateralis the contour of the frontal region differs markedly from skulls M2 and M3 (Fig. 3). In contrast to the vertical, overhanging, foreheads of these two skulls, the forehead of M4 curves evenly backwards to a rather more rounded vault. The parieto-occipital region resembles that of the Bush-Boskopoid type, but there is a prominent external occipital proturberance which interrupts the otherwise almost hemispherical contour. The nuchal plane is concave and faces more downward than backwards.

The mastoid process is larger than that of M2, and the fairly deep digastric fossa grooves the base of the skull rather than the medial side of the mastoid. The supramastoid region is Boskopoid in character, but the tympanic ring is thicker and more rugged than in M2.

The reconstructed orbit is rectangular and its height is less than that of the average Negro. The axis is oblique and is directed downwards and slightly backwards. The malar region of M4 is distinctive in that the infero-lateral angle of the orbit is prominent, while the plane of the body of the Zygoma tends to be flattened and faces more laterally than anteriorly.

Discussion.

In describing this collection of skulls, two principal groups have been differentiated, showing respectively a predominance of Negro and Bush-Boskop features. In view of the fact that neither of these groups corresponds exactly to previously described Negro and Bush-Boskop types, further qualification of this classification is essential.

The skulls of the first group, though they exhibit some variation which may be due to sex differences, differ consistently in certain respects from the typical Negro. They are less robust, more characteristically hyperdolichocephalic and less prognathous. Those of the second group, while they conform to the Bush-Boskop type in their lateral contour and in many details, depart conspicuously from it in their ovoid or ellipsoid contour in Norma Verticalis. The burnt skull, M4, is in many respects intermediate between the two groups. This could be explained by assuming that it represents either a transitional form or a hybrid between the Bush-Boskop and Negro groups. On the other hand it seems reasonable to postulate that M4 and M2 are respectively male and female skulls of the one physical type, which has been described as "predominantly Bush-Boskop".

It has not yet been possible to correlate the physical variations shown by these skulls with any definite cultural differences between the burials. Some burials, including those from which

came skulls M2 and M3, were more thoroughly disturbed, and may thus be older than the remainder. Even the less disturbed burials, which were accompanied by articles of Bantu culture, no longer seem to be the object of any cult or taboo.

While it is not yet possible to assign these different skull types to any chronological sequence, they can be compared with other skeletal material from Rhodesia and adjacent territories, which shows a similar variation in proportions of Negro and Pre-Negro features:—

(i) *Mapungubwe*: Galloway (1937) described the remains of eleven skeletons which were found in association with this "Ancient Bantu civilisation on the Limpopo". He found that the skulls showed from ten to twenty per cent. of Negro features and demonstrated a preponderance of Bush-Boskop characters. The conclusion is that "it is a Bush-Boskop people showing sporadically a few Negro features. . . . The scarcity of Negro features can mean only that they are alien. . . . Mapungubwe represents a homogeneous Bush-Boskop population physically akin to the post-Boskop inhabitants of the coastal caves".

(ii) *Penhalonga*: Penhalonga is less than one hundred miles from Marandellas, and in association with some "Pit-circles" in this district were found three skeletons which were described by Galloway (1936). The skulls were found to show varying proportions of Bush-Boskopoid and Negro features; but "taken together these skeletons tell a different story; in each of them there is a small but definite substratum of Negro features which indicates their affinity to a Negro Bantu-speaking people. The great preponderance of pre-Negro features, especially the Bush of "A" and the definite Boskopoid affinities of "C" suggest that these . . . . individuals represent an early stage of Bantu settlement in Rhodesia, since the Negro imprint is so poorly marked on the pre-Negro indigenous substratum".

(iii) *Rusape*: Rusape is situated between Marandellas and Penhalonga and from the "ancient workings" of this district have come several human skeletons. Two of the skulls from this Cornucopia site have been described by Wells (1939), who postulates that "These non-Negro predominantly Boskopoid skulls represent a type of population which . . . preceded the Bantu-speaking Negro; . . . individuals found at the Cornucopia site might have belonged to a Bantu-speaking population, but this could only have been the result of a wholesale absorption of the pre-Negro by an invading Negro type". Discussing the similarities between these and other Rhodesian skulls, Wells writes: "While the evidence does not permit us to identify the

Cornucopia with the Mapungubwe people, they belong to a physical type very similar in most respects."

(iv) *Skeletal material discussed by Professor Drennan*: Also of considerable interest in this discussion are several isolated groups of skeletal remains which have been reported at various times by Professor Drennan. Abstracts from these reports have been published by Phaup (1939); and Drennan, in summarizing his findings (1939), wrote: "Although it is legitimate to class them all as prehistoric Rhodesians . . . it is important to subdivide them into two groups . . . those with, and those without association with mining activities. I consider the Mazoe specimen from the Carolina claims; the specimens from the Eureka Mine, Sipolilo; and the specimen from the van Niekerk ruins (Inyanga) to have belonged to the mining group. They all belong to the same physical type, and are all either females or children. The Makoni skull . . . also belongs to the same physical group, but the group of skulls from the cave enclosure at Penhalonga seems to me more modern, and to approximate more than the others to the existing native types."

The salient features of Drennan's reports have been tabulated in Table Three.

Professor Drennan deplores the application of a "hyphenated word made of two terms" to a "complex which includes three or four different elements". Perhaps we shall soon have sufficient evidence to enable us to reject all such hyphenated words, which are used to denote this physical type, in favour of the term "pre-Negro".

(v) *Other remains*: A number of skulls from different parts of Rhodesia have been described at various times by Shrubsall and Keith. Both authors concluded that all their specimens were of Negro type.

The first, or predominantly Negro, group of skulls from Marandellas apparently has a close affinity with the skulls from Penhalonga discussed by Professor Drennan. This conclusion is supported by an undescribed skull which was recovered from a rock-shelter burial at Penhalonga, and which is now in this Department. Our specimens are consistent both with Drennan's remark that they approximate closely to the existing Negro, and with his reference to "the possibility of Bush or Pygmy admixture". Some of the skulls described by Keith are also apparently of this somewhat modified Negro type.

It is, however, doubtful whether we are justified in relating our "predominantly Bush-Boskop" group with the material similarly diagnosed by Drennan, Galloway and Wells. Though there is distinct evidence of Bush-Boskop features in all this material, it is evident that several of their specimens showed

these features to a far greater extent than the Marandellas skulls.

From this accumulation of evidence it seems reasonable to conclude that these Rhodesian discoveries represent successive stages of the Negro infiltration into an indigenous race whose physical affinities were purely Bush-Boskop. In this case the "predominantly Negro" group could represent a more advanced, if not chronologically later, stage of the same process; in which the Negro characters have become dominant, but the pre-Negro elements have not been as completely eradicated as in the modern population. This possibility is further borne out by the meagre cultural evidence available; the cultural associations of the "predominantly Negro" group are Bantu in type, and thus would indicate that there occurred an imposition of Bantu culture on the subordinate pre-Negro race.

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TABLE 1	Predominantly Negro Group						"Bush-Boskop" Group		M.4
Comparative Cranial Measurements	*M1*	*M5*	*M6*	*M7*	*M8*	*M9*	*M2*	*M3*	*M4*
Cranial Length . . .	18.1	18.7	18.3	17.7?	18.5	19.1	18.1	17.6	18.5
Cranial Breadth . . .	12.4	13.0	12.2	12.0?	12.0	13.2	13.1	13.1	12.8?
Basio-Bregma Ht.	12.7	12.6	12.5	—	13.4	13.9	11.4?	—	13.6
Least Frontal B.	8.6	9.7	9.1	9.5?	9.1	9.5	10.0	9.4?	10.3
Upper Facial Ht.	7.3	6.9?	6.8	—	7.2?	6.5	—	—	—
Ext. Biorb. B.	9.8	11.0	10.1	10. ?	10.6	10.5?	—	—	11.5?
Bizygomatic B.	12.0	13.1	11.8	11.9?	12.7?	12.7	—	—	—
Orbital Breadth . . .	3.9	4.0	3.8	3.7	4.0	4.1	—	—	4.2?
Orbital Height	3.7	3.2	3.3	3.4	3.5	3.5	—	—	3.4?
Interorbital Dia. . . .	2.1	2.5	2.3	2.3	2.2	2.3	—	—	—
Nasal Height . . .	4.7	4.7	4.7	—	5.1	4.7	—	—	—
Nasal Breadth . . .	2.6	2.5	2.5	—	3.1	2.7	—	—	—
Max. Alv. Breadth	5.6?	—	6.3?	—	6.1	6.6	—	—	—
Max. Alv. Length . . .	—	—	5.5?	—	5.7?	5.6	—	—	—
Palatine Breadth	3.4?	—	4.2?	—	3.5	3.9	—	—	—
Palatine Length . . .	5.0	4.9	5.2	—	5.2	4.5	—	—	—
Bicanine Breadth	4.1	4.1?	4.0?	—	4.3?	4.2	—	—	—
Foramen Magnum B. . .	3.0	3.1	3.1	—	3.0	—	3.1	—	—
Foramen Magnum L. . .	4.0	3.4	4.1	—	3.6	4.2	—	—	—
Cranial Capacity	1345cc.	1320cc.	1250cc.	—	1235cc.	1430cc.	1250?cc.	—	—

TABLE 2	Predominantly Negro Group.						„ Bush-Boskop " Group.		M4
Comparative Cranial Indices.	*M*1	*M*5	*M*6	*M*7	*M*8	*M*9	*M*2	*M*3	*M*4
Cephalic Index	68.5	69.5	66.7	67.8?	64.9	69.1	72.4	74.4	69.2?
Altitudinal Index	70.2	67.4	68.3	—	72.4	72.8	63.3?	—	73.5?
Fron. Par. Index	69.4	74.6	74.6	79.2?	75.8	72.0	76.3	71.7?	80.5?
Upper Facial Index . .	60.8	52.7?	57.6	—	56.7	51.2	—	—	—
Orbital Index	94.9	80.0	86.8	91.9	87.5	85.2	—	—	81.0?
Interorbital Index	21.4	22.7	22.8	22.3?	20.8	21.9?	—	—	—
Nasal Index	55.3	53.2	53.2	—	60.8	57.5	—	—	—
Max. Alv. Index	—	—	114.5?	—	107.0?	117.9	—	—	—
Palatine Index	68.0?	—	80.8?	—	69.2	86.7	—	—	—
Foramen Magnum Index . .	75.0	91.2	75.6	—	83.3	—	—	—	—

TABLE 3

	Site of Discovery	*Material*	*Remarks*
A	Penhalonga, Umtali	3 male skulls; 1 female skull.	" . . . the four skulls . . . form a homogeneous group and are definite negroes; . . . the cranial capacity . . . . makes one think of the possibility of Bushman or Pygmy admixture."
B	Makoni District	" Recent Adult skull."	" The features of the skull are typically Bantu, and it resembles very closely two Mashona skulls with which I have compared it."
C	Carolina claims, Mazoe.	Female skeleton.	From an old mine shaft, associated with " slave bangles." " . . . The skull is somewhat smaller than the female one from Penhalonga, but very comparable in its proportions, and definitely Negroid in every respect."
D	Eureka mine, Sipolilo	Skeleton of infant.	" The measurements . . . show that this specimen is very similar to the youngster that Galloway calls Bush-Boskop . . . In my opinion this youngster was a member of the race that lived and worked at Mapungubwe and Bambadyanolo . . ."
E	Inyanga	Skull fragments.	" I can see from the teeth and other features that the skull is definitely that of a negress."
F	Oceola mine	Skull.	" The first thing which strikes one is the curious way in which it blends the features of Bushman, Hottentot and Bantu types . . ."
G	Planet mine, Bulawayo	Skull.	" . . . whilst it showed certain Bantu characters, it was predominantly Bushman . . . I would now be prepared to classify this specimen as also belonging to the Bush-Boskop group."

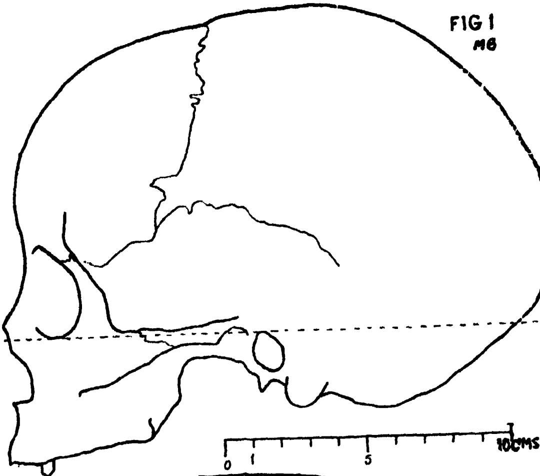

FIG 1
M6

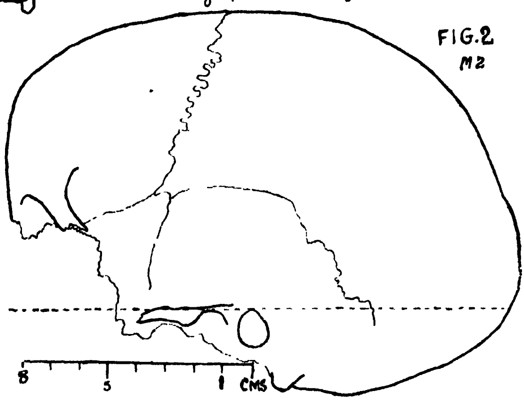

FIG. 2
M2

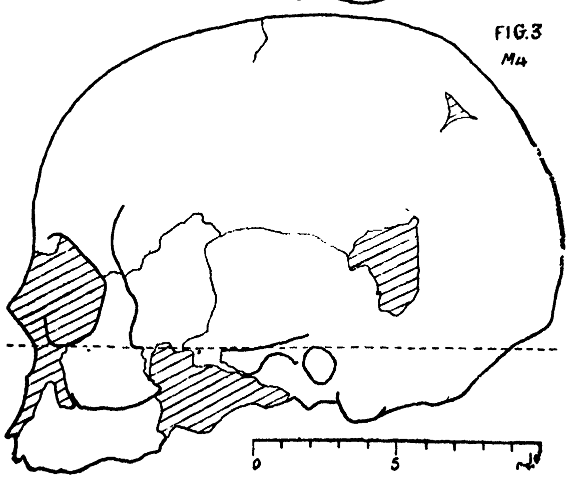

FIG. 3
M4

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THE CAVETTO IN BORED STONES: A RETROSPECT

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Read 2nd July, 1946.

The occasion of the last meeting of our Association in Pretoria was a momentous one for our Section (E). It was then that we held a round table conference and agreed to break away from the orthodox European archaeological terminology which we had until then tried to follow, and to establish a terminology of our own. The report which formed the basis for discussion is to be found in the Journal of the year 1926 (Goodwin). This was exactly twenty years ago and it is pleasant to recall that most of those who attended the conference are still in our midst and are still active workers. Unfortunately a few are no longer with us and I feel that this is an occasion when it is meet that one of us who was present should recall their contributions and do homage to them as pioneers. Before I do so, however, and before I come to the descriptive part of my paper, you will, I hope, permit me to digress for a few minutes to review some of the more important effects of the decisions taken here twenty years ago.

The establishment of a characteristically South African terminology was an experiment which the passing years have more than justified. Not only are the main cultural terms selected at the time still in use by us, but some of them have found their way into other parts of the continent—most notably into the Rhodesias, the Belgian Congo, into Portuguese East Africa, Tanganyika, Kenya and Uganda, where remains that reflect man's industry in prehistoric times are more closely related to those from South Africa than they are to those found in Europe. But more important perhaps is the fact that our terms are now very widely, if not universally known and understood and their use has impressed upon men the fact that while we have certain old cultures here which afford direct typological links with various stages of the Stone Age in this country and those noted in other parts of the Old World, there are differences and differential developments in the main cultures as these occur in the continental extremes penetrated by men during the Stone Age, which demand distinct descriptive terms. The differences are not so marked in the Old Palaeolithic or Earlier Stone Age where broad regional prefixes may occasionally be sufficient to distinguish certain stages of development of the earlier cultural divisions of the Great Hand-axe Culture, but

when we pass into the later divisions of this culture and then into the Middle Stone Age, we find the differences are so great that in the interest of clarity alone, they demand the abolition of common terms and the introduction of specific regional terms. This demand becomes more and more insistent as we proceed up the scale of man's development. For example, the Mousterian Culture is distinctly French; the Solutrean, Magdelinian, Azilian, etc., are distinctly confined to certain areas of Europe while the Stillbay, Smithfield and Wilton Cultures are distinctly South African, despite the existence of such marked typological affinities as occur, for example, in the finest products of human industry in stone in the Solutrean of Europe on the one hand and in the Stillbay of South Africa on the other.

The explanation of the more marked affinities between northern and southern occurrences of human industry in stone during Old Palaeolithic times in Europe and the Earlier Stone Age in South Africa, is I think, largely to be sought in the slow rate of human progress and man's naturally deep-seated conservatism during the time that elapsed between the making of hand-axes in these continental extremes and the making of their prototypes in the region in which the Great Hand-axe Culture arose and from which it slowly spread. For example, the evidence before us strongly suggests that the essential home of the Great Hand-axe Culture is to be sought in Equatorial Africa; that this Culture spread in waves from this region northwards into Europe and Asia and southwards into the Union; and that because of man's comparatively slow evolution during that remote period, the earliest elements which characterise this widespread Culture underwent little, if any appreciable change during the outward spread of those who carried it from its centre of origin. In other words, it would seem that the Great Hand-axe Culture originated in and was diffused over Africa and into Europe with little change while the main tool-type was Abbevillian in form. Therefore we may have a French Abbevillian Culture in the north and a Rhodesian Abbevillian in the south and so on. Man's skill and expanding genius as reflected in his craftmanship continued to develop so slowly and so conservatively that we may equally well have an early French Acheulean on the one hand and an Angola Acheulean on the other.

The only complication and the only possible objection to the use of common terms to describe occurrences of the Great Hand-axe Culture in northern and in southern latitudes, is the persistence among European prehistorians in believing that while this so-called core culture was evolving through the Abbevillian and Acheulean Stages in Europe, there existed contemporaneously with those who practised it a people with a pure flake-culture, the industrial development of which passed through several evolutionary stages characterised by various divisions of the Clacton and Levallois Cultures. It is the origin

and influence of this independent Flake Culture on the Great Hand-axe or Core Culture in Europe that makes the use of a common terminology so difficult when we wish to avoid misunderstanding and confusion. Therefore we in South Africa have generally adhered to the terms agreed upon at the round table conference held here twenty years ago. Broadly speaking we know that our Stellenbosch and Fauresmith Cultures remain the South African counterparts of the European Abbevillian and Acheulean; the former in *intimate* association in South Africa with Clacton and Proto-Levallois elements, the latter in *intimate* association with Levallois (Goodwin: 1933. Van Riet Lowe: 1945). Nevertheless progress in the archaeological exploration of Africa has been so great during the past decade alone that the time has now arrived for us to hold another but more representative round-table conference to reconsider this all-important question. It is therefore very gratifying to be able to report that such a conference is to be held in Kenya next January; the conference to be Pan-African instead of merely South African. I am confident that this larger conference will emphasise the pre-eminent importance of Africa in all matters that relate to human origins and the diffusion of early human cultures and lead, one may hope, to a better understanding of these problems.

Our last meeting in Pretoria was also important for another reason. Among those who took part in the proceedings were two of our most distinguished pioneers in the field of prehistoric studies—pioneers who are unfortunately no longer in our midst, and to whom I wish to-day to pay a special tribute. I refer to the late Mr. F. J. Jansen and the late Dr. T. N. Leslie. Jansen presented a paper on " A New Type of Implement from Victoria West " and Leslie one on " The Stone Age Industry of Vereeniging ". Both were published in the Journal of that year. Jansen's contribution led to the recognition of the Victoria West industry as including a Proto-Levallois technique which was practised as an integral part of the Stellenbosch Culture thus emphasising a fundamental difference between the European and South African counterparts of the Great Hand-axe Culture when the principle tool was a bifaced hand-axe of Acheulean form. Leslie's contribution dealt with a collection of stone implements he had made in the valley of the Vaal on the Town Lands of Vereeniging where he started collecting in the early nineties of last century.

Much water has flowed down the Vaal since these papers were read and much progress has been made in prehistoric exploration. The Vereeniging town lands have been found to contain remains not of a single human industry as this pioneer once thought, but remains of human activities throughout the Quaternary Age. Since man first appeared there in Lower Pleistocene times, possibly even in the Late Pliocene, the bed of the Vaal has been lowered by 100 feet and the stream has in

places undergone a lateral displacement of several miles. We have rolled remains of a Pre-Stellenbosch core-cum-flake "Pebble Culture" well embedded in an iron-stone band at the base of gravels aggraded in a 100 ft. terrace, and remains of a developing series of core-cum-flake Stellenbosch I tools of Clacto-Abbevillian facies embedded in the Older Gravels of a 50 ft. terrace. It is a happy augury for the future that sites on both these terraces have been preserved and an adequate acreage set aside for future excavators by the Commission for the Preservation of Natural and Historical Monuments, Relics and Antiques. The Proclamation of these areas was made possible by legislation passed since last we met here, thus marking another great step forward. From the body of the Younger Gravels in the river now permanently inundated by a barrage, we have a large series of Middle and Upper Stellenbosch remains in various physical conditions, followed by Fauresmith, Middle and Later Stone Age remains. Among specimens derived from the Later Stone Age, Dr. Leslie exhibited a unique bored-stone. In referring to it he said: "In the common type of perforated stone, the hole is either conical, or roughly irregular, bored from both ends. This implement is always of hard durable stone, such as quartzite or dolerite, and is generally rough in outside appearance. The specimen figured, however, is very different (Plate XVIII, Fig. I). It is of steatite, not found within fifty miles of Vereeniging. The hole is perfectly cylindrical, with definite cavetto at one end and the outside is polished. Perhaps the stone had some ceremonial significance" (Leslie, 1926).

As this specimen was unique, several suspected at the time that the concave moulding or cavetto which occurs within a flattened collar round the cylindrical perforation at one pole only, was not an original feature of the stone. Despite the fact that patination of the various surfaces exposed in the general grinding and polishing processes and in the careful shaping and polishing of the cavetto, provided no clue to the possibility of these surfaces having been ground and polished at different times, it was felt by some that the unique embellishments were not original. Some even maintained that the cavetto had been ground out by means of a metal tool. But Dr. Leslie stoutly maintained that the entire shape was the original work of an individual of the Stone Age. Admitting that he had seen such flattening at the poles of bored stones without a cavetto after long use as door-weights, he nevertheless maintained that the entire shape of the Vereeniging specimen was original. And so this interesting bored stone remained unique and provided much food for thought and argument down the years.

After twenty years I have come to you to-day with a second specimen. (Text Fig. I). It was found by Mr. D. Stokes at Grasfontein in the Lichtenburg district of the Transvaal and generously donated by him to the museum of the Archaeological

Survey last year. Despite appreciable damage, it is the twin of the Vereeniging specimen: of dark bottle-green steatite, well rounded and polished, with a slightly tapered cylindrical perforation, decorated at one end with a highly polished cavetto within a flattened and highly polished collar which merges finally into the contours of the outer well-rounded surface—the patina of all these polished surfaces being uniform. The dimensions of the two specimens are:—

		Vereeniging.	*Grasfontein.*
Mean Diameter	(across equator) in cms.	13.4	13.1
„ „	(pole to pole) in cms.	7.6	7.4
„ „	of collar round cavetto in cms.	8.0	7.8
„ „	of outer circle of cavetto in cms.	5.5	5,6
„ „	of inner circle of cavetto or perforation in cms.	3.5	3.4

This Grasfontein specimen is therefore astonishingly like that from Vereeniging and completely vindicates Dr. Leslie. I submit it to this meeting as a tribute to a great and uncommonly versatile pioneer; to a man who not only distinguished himself as a botanist, a palaeobotanist, a geologist and a humanitarian, but also as an archaeologist who was among the first to collect stone implements in the Transvaal well over half a century ago and thus helped to lay the foundations of archaeological exploration in this Province. So far as I am aware, he was preceded only by Penning who exhibited stone implements from Pretoria and Origstad at a meeting of the Anthropological Institute in London on 9th March, 1886. (Penning, 1886.) We thus see that the soil on which Pretoria stands first figured in the world of prehistoric archaeology over sixty years ago.

If exploration continues to expand during the next twenty years as it has expanded since last we met here, and if each of the decades which lie immediately ahead produces a Leslie and a Jansen, we may look forward with confidence to further great advances in our science.

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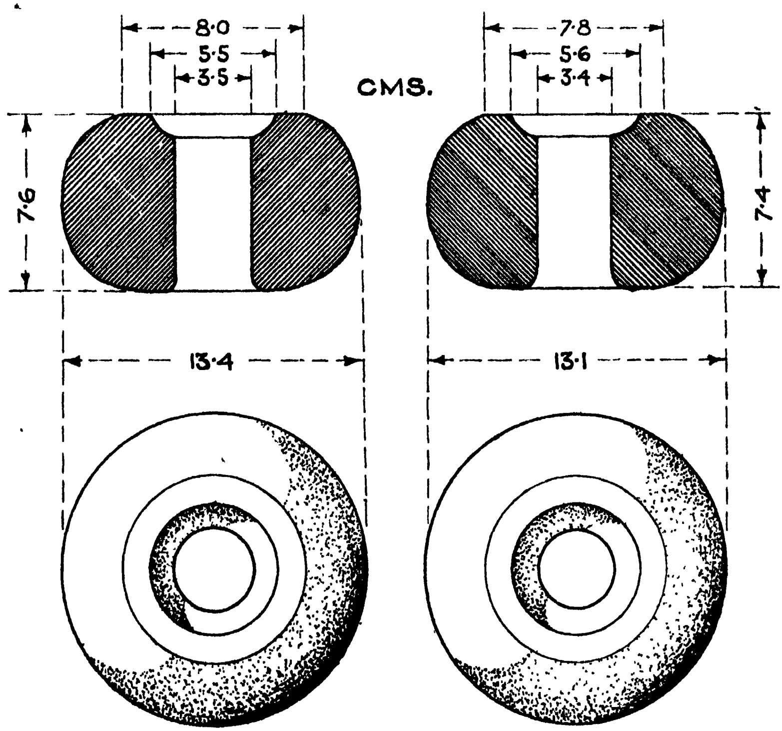

VEREENIGING GRASFONTEIN

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FLAKE TOOLS AND ARTEFACTS IN THE STELLENBOSCH-FAURESMITH TRANSITION IN THE VAAL RIVER VALLEY

BY

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1. The Problem.

When the joint work of the Geological Survey and the Archaeological Survey on the gravels of the Vaal River Basin came to an untimely end in 1936, several problems had not yet been solved. In this paper I propose to deal with one of them in the light of subsequent work in the area. By 1936 the development of the Stellenbosch Culture had been traced through five stages, each correlated with stratigraphical phenomena which were interpreted to reflect successive climatic fluctuations.

The fifth or final stage of the Stellenbosch Culture occurs on the final deposits of the Younger Gravels (Younger Gravels III) and in the thin band of current-bedded sands immediately overlying them. These sands and those which overlie them were associated with the decline of the great wet phase of which the Younger Gravels are evidence. Above this thin band of current-bedded sands lies an enormous blanket of calcified sand and silt which at Riverview Estates covers an area of about ten square miles to a thickness of some thirty feet. Occasional local unconformities and lenses of lime containing fresh water achatina shells in this highly calcified deposit indicate that at certain times and places conditions during its deposition could not have been entirely inhospitable. On the surface of the calcified sands we find remains of the Fauresmith Culture which accumulated during a wet phase which peneplaned the surface of the calcified sands and resulted in the deposition of the Youngest Gravels now only preserved in tributaries of the Vaal. In this paper we shall be concerned with the prolonged period of declining precipitation and increasing inhospitable conditions which intervened between the Stellenbosch and Fauresmith Cultures.

Since the publication of the work by Söhnge, Visser and van Riet Lowe (1937) investigations have been continued by the Archaeological Survey. In this the Survey has enjoyed the able co-operation of Mr. L. M. Larsen, a diamond-digger at Riverview Estates, whose deep interest, encouraged and guided by the Survey, has made him a most meticulous collector and a recorder whose observations are completely reliable. During the past ten years Mr. Larsen has presented much well-documented material to the Archaeological Survey and his work has been constantly verified by the Staff of the Survey.

2. Description of Flake Artefacts associated with Stellenbosch V.

The bifaced tools of Stellenbosch V found on the surface of the Younger Gravels or in the current-bedded sands which immediately overlie them have been fully described by van Riet Lowe (1937), but smaller true flake tools had not been found at that time. The published picture is therefore incomplete in a very important respect.

In the vicinity of Larsen's House (Site II) a considerable number of smaller artefacts have been found in association with Stellenbosch V handaxes and cleavers.

(*a*) *Cores*: A large number of cores are most enlightening. (Fig. I, 1 and 2.) These vary in diameter from about 5 cm. to about 11 cm. The majority are on waterworn pebbles and retain varying amounts of cortex. The simplest specimens are waterworn pebbles from which a few flakes have been struck. When a number of flakes have been removed the core assumes an irregular polyhedral form. "Prepared" striking platforms do not occur.

It will be apparent that the striking platforms of flakes struck from such cores will fall into one of three categories.

(1) Natural cortex of pebbles selected;

(2) Single negative flake scars, commonly called "plain" striking platforms;

(3) Boldly or incidentally facetted platforms with two or occasionally three facets. It is important to distinguish between this simple, incidental facetting and the much more elaborate technique implied by the deliberate and purposeful preparation of a striking platform by the removal of a number of small flakes which characterises the true Levallois technique. To emphasise this difference I shall in describing flakes refer to "incidentally facetted" as distinct from "prepared" striking platforms.

With a few exceptions the negative flake scars on the cores are not deep, and the angles between flake scars and striking platforms are, on the whole, not obtuse but approximate to 90°. These features are consistent with the corresponding features on the flakes. In other words, we are presented with a "hammer-on-stone technique" and not with an "anvil technique".

(*b*) *Blades*: These are narrow and comparatively long and are generally somewhat larger than the flakes which are more erratic in shape. The largest blade in the assemblage (Fig. I, 3) is 12 cm. long, 5 cm. maximum width and 1.7 cm. maximum thickness. The half of the upper face remote from the butt consists of cortex of the rounded boulder from which it was

struck. The striking platform is small and appears to have been facetted. The end remote from the butt is square and on both faces shows flaking resulting from the use of the tool in the manner of a plane.

Six other blades are about 8 cm. long and vary in maximum width from 3 cm. to 5 cm. Three of them have plain obtuse-angled striking platforms; in the remainder the striking platforms are small and indefinite.

(c) *Flakes*: The flakes are more erratic in form and asymmetrical. They vary considerably in size and thickness. The smallest among them measure about 3 cm. across, are comparatively thin, with plain or incidentally facetted striking platforms, and may have been struck from handaxes in the process of manufacture. The larger flakes however do not appear to have been derived in this way, and were struck from recognizable cores. One of these resembles a convergent longitudinal point such as typify Middle Stone Age industries, but the striking platform shows only two incidental facets and the bulb of percussion is situated asymmetrically on one " shoulder " of the point. This specimen (Fig. 1, 4) measures 7.4 cm. long, 4.5 cm. maximum width and 1.5 cm. maximum thickness. More typical of these erratic flakes is that shown in Fig. 1, 8, which has an approximate diameter of 5.5 cm. and maximum thickness of 2 cm., a plain striking platform, diffused bulb of percussion and an obtuse angle between the striking platform and flake surface.

(d) *Trimmed Tools*: These are much less numerous than handaxes and cleavers with which they are associated in Stellenbosch V, but a sufficient number have been found to prove that the culture did not depend entirely on bifaced tools. They show no consistency in form and cannot be assigned to specific " types ", but are rather in the nature of scrapers or points made on any convenient flakes or fragments. A number of these tools is illustrated in Fig. I; 3, 5, 6, 7, 9. No. 3 is the end scraper on a blade already described in detail under " Blades ". No. 5 is a most elaborate tool, a combined hollow scraper and point or single-shouldered piercer. Much of the flake surface has been trimmed away including the butt so that the nature of the original flake cannot be wholly determined. No. 6 is a small point, triangular in cross-section, on a flake struck from a rounded pebble. The striking platform and much of the surface of the tool is waterworn untouched pebble-cortex. No. 7 is a broad quadrilateral flake, steeply and boldly trimmed along the edge remote from the butt. The striking platform shows one large and several smaller facets. The flake surface is untouched and shows a marked " bulbar scar " and fissures. No. 9 is a crude, very thick flake, much of the surface is cortex, as is the striking

platform. Three of its edges have been crudely and steeply trimmed by secondary working to form a scraper.

3. Description of Artefacts from Calcified Sands Overlying Stellenbosch V.

When the report on the Vaal River Survey was published, the calcified sands overlying the horizon which yielded Stellenbosch V artefacts, were thought to be sterile. This was taken to indicate that conditions had become too inhospitable to support human occupation of the area. Subsequent discoveries of occasional bifaced tools and smaller artefacts in these deposits which overlie the current-bedded sands, and Younger Gravels III deposits, show that the population of the area became extremely sparse but did not cease completely until at least half the thickness of sand had been deposited.

Site I: The Homestead, Riverview Estates.

The first site at Riverview Estates to yield artefacts from the calcified sands was a series of digger's shafts along the fence which encloses the Homestead area to the South-West of the gate leading to the Homestead and some 400 yards East of the Homestead. This material includes 7 handaxes, 1 cleaver, 48 flakes, 4 cores and a few nondescript fragments. All the material is unrolled and encrusted with the calcarious matrix in which it was embedded.

(*a*) *Handaxes*: Three specimens made of Ventersdorp diabase are about 16 cm. long and 8.5 cm. maximum width and about 4 cm. maximum thickness. They are refined, with sharp straight-line edges, made on flakes, and typologically might be common to any assemblage of advanced Stellenbosch or Fauresmith Cultures. A fourth specimen of Ventersdorp diabase is much larger, being 24 cm. long, 13.5 cm. maximum width and over 6 cm. thick, showing thick crude flaking, somewhat ragged or zigzag edges and retaining a considerable amount of the cortex of the boulder of which it was made. It is typical of Stellenbosch II and is somewhat of an anachronism in the deposit in which it was found.

Three smaller handaxes are typical of the Fauresmith rather than of the Stellenbosch culture. The largest of these which is indurated shale is 2.5 cm. long, 5.5 cm. maximum width and 3 cm. maximum thickness. The flaking is such as characterises good early Fauresmith handaxes.

(*b*) *Cleaver*: The butt has been recently damaged, but the present length of the specimen is 12 cm., maximum width 8 cm., thickness 3 cm. It is made on a side flake of Ventersdorp diabase and exhibits the characteristic parallelogram cross-section which accompanies the Victoria West I technique of Stellenbosch III.

(*c*) *Cores*: There are three cores from this site. The largest is a very thick flake, some 15 cm. in diameter and of 10 cm.

maximum thickness, giving it almost a pyramidal form with the flake surface as its base. By blows struck round the perimeter of the flake surface a number of thick, short flakes have been removed. The majority of the flakes must have had plain striking platforms. A portion of the perimeter covering the bulb of percussion has been roughly trimmed, and flakes struck from this portion must have shown two or three incidental facets on the striking platforms. Another core is on a water-worn pebble and in shape resembles a very crude Stellenbosch I or Abbevillian type handaxe (Fig. II, 1). The third is small, more reminiscent of crude Levallois high-backed disc cores such as may be found in the Fauresmith Culture.

(*d*) *Flakes*: Apart from a number of fragments which tell us little, there are thirty flakes from the calcified silts at this site. Of these, twenty-five are crude and five are more advanced. The crude series are most interesting as they have not yet been noted either in the preceding Stellenbosch nor in the succeeding early Fauresmith Cultures. They are small, short and broad, of erratic and asymmetrical shape (Fig. II, 2, 3, 4, 7, 8). A fair average specimen would have a diameter of about 5 cm. A striking characteristic is their comparatively great thickness at the butts. In four the striking platform is a natural surface, in sixteen the platforms are plain flake surfaces, and in five there is crude facetting resulting from the removal of two or perhaps three bold flakes. Nearly all have obtuse angles between the striking platforms and the positive flake scars suggesting that they were detached by an "anvil technique".

The remaining five flakes are more refined and reflect a true Levallois technique of a degree of development which is amazing at so early a stratigraphical horizon. The two most striking specimens in this group are illustrated in Fig. II, 5 and 6.

(*e*) *Trimmed Tools*: These are rare, but two excellent specimens are illustrated. Fig. II, 9 is a carefully trimmed scraper on a re-directing flake with a plain, wide-angled striking platform, while Fig. II, 10 is a carefully trimmed point on a crude flake.

(*a*) Site II: Larsen's House.

Between the Homestead and Larsen's House is a windmill which stands some 500 yards south-west of Larsen's House within a fenced area. Just outside the northern corner of the fence is an excavation which yielded eight specimens from the calcified sands, viz. 3 handaxes, a core, 2 flakes, a scraper, and a point. The largest handaxe is a perfect pointed "limande" 13 cm. long, 8 cm. maximum width and 3 cm. max. thickness. The smaller handaxes are broken, but might have been 11 and

6.5 cm. long respectively. They are very steeply and crudely trimmed. They occur at a depth of 6 feet below the peneplaned surface of the calcified sands and 22 feet above the Younger Gravels.

The flakes are small, short for their breadth, and very thick at the butt. (Fig. III, 1, 2.) The striking platform of one is a single negative flake scar and the angle is obtuse; in the other the striking platform is boldly facetted and the angle is approximately 90°. The trimmed point (Fig. III, 4) is on a thick flake, the striking platform of which is weathered cortex which extends also over a portion of the upper face of the tool. The secondary trimming is steep but meticulously made and elaborate. The scraper is a small crude broad flake of quartzite with a small plain striking platform, the longer edge coarsely trimmed to form a scraper.

(*b*) Site II: Larsen's House.

Some 200 yards west of this site, next to the northern fence of the enclosed area, are two other excavations which have given us material from about 8 ft. below the surface of the calcified sands. From there we have two handaxes, two cleavers, four flakes and one core. The larger handaxe is of indurated shale, of good "limande" form showing very thin and controlled flaking. It would do credit to any Stellenbosch V assemblage. It measures 19 cm. long, 10 cm. maximum width and 4 cm. maximum thickness. The second is roughly made on a water-worn slab of indurated shale. On one face the flakes removed were thin; on the other thick flakes have been removed. It has a narrow cleaver edge rather than a point and might be classed as a chisel. It measures in length 15 cm., maximum width 9 cm., maximum thickness 4.3 cm. Both cleavers are on large side flakes of Ventersdorp diabase. Both have pointed butts. The larger specimen has an oblique cutting edge, and measures 18.5 cm. long, 11 cm. maximum width, 4.7 cm. maximum thickness. The other shows a much trimmed flake surface but the upper face consists almost entirely of rolled cortex. It measures in length 17.5 cm., width 9.7 cm., thickness 4.5 cm. The flakes are extremely crude. They are thick and asymmetrical in form. In the two illustrated the striking platforms are plain flake surfaces and the angles are obtuse. In the remainder the striking platforms are missing. The flakes are in the same deposits and have the same *état physique* as the bifaced tools and cannot be dissociated from them.

4. Makapan Caves.

For material to be compared with that recovered from the calcified sands at Riverview Estates, we have to turn to the Cave of Hearths in the Makapan Valley. (Van Riet Lowe, 1938 and 1940.) This takes us to the drainage area of the Limpopo. With the collaboration of Mr. A. G. White of the Transvaal

Museum, I undertook in 1940 the examination of the considerable quantity of collapsed breccia from this cave. This work, together with the results of other visits to the site, have provided us with a considerable collection of fossils and some hundreds of artefacts. The fossils await description, but the artefacts have been referred to at some length by Van Riet Lowe (1943).

About a dozen bifaced tools (handaxes and cleavers) have been found. They are of Upper Stellenbosch type and two have been illustrated. Although the bulk of the material comes from collapsed breccia there is no reason to dissociate the bifaced tools from the rest. In comparison with the quantity of flakes and cores, the bifaced types are rare.

The cores are facetted polyhedrals with deep, short negative flake scars. Striking platforms are not "prepared", but are either plain or, when they include portions of more than one negative flake scar, incidentally facetted. The angles between flake scars and striking platforms are in most cases obtuse. Cores vary in size from about 4 cm. to about 10 cm. in diameter. (Fig. IV, 1, 2.)

The great majority of the flakes are short and "stubby" and very thick at the butts. (Fig. IV, 3-8.) Striking platforms are plain or incidentally facetted, and set at an obtuse angle to the flake surfaces. Trimmed tools are extremely rare and consist entirely of such flakes from which a few steep flakes have been removed by secondry trimming. A few more refined flakes are exceptional but must be mentioned. (Fig. IV, 9,10.) They are thin and slender and contrast markedly with the much more numerous thick-butted types. Striking platforms are approximately at right angles to the flake surfaces but are either plain or incidentally facetted. True "preparation" of striking platforms is absent.

5. Discussion.

The objects of this paper are two-fold. Firstly, attention is drawn to the presence and significance of flakes and flake tools in the Stellenbosch V Culture of the Vaal River Basin. Secondly, artefacts are described from the calcified sands, which overlie strata which had previously yielded Stellenbosch V remains and which were at first thought to be sterile.

In Stellenbosch V the bifaced are so numerous and striking that they tend to overshadow the humbler but equally important flakes, but the Abbé Breuil first drew attention to the latter, when he pointed out the significance of the Victoria West technique as the precursor of the Levallois technique (1930). Subsequently Goodwin (1933) stressed this point and it has recently been further elaborated by Van Riet Lowe (1945).

In Stellenbosch IV we have the Victoria West II or Proto-Levallois technique with its large end-flakes struck from "perde-

hoef" or "horsehoof" cores which occasionally differ little from early Levallois cores. By Fauresmith times the Levallois is fully developed and an integral part of the culture. Between these lie Stellenbosch V and the sparse habitation of the comparatively dry period which followed it. The flakes and cores described in this paper provide the link between the Proto-Levallois of Victoria West II and the true Levallois of the Fauresmith, though it must be admitted that the most advanced Victoria West II cores and flakes are even nearer the true Levallois in general characteristics.

The closest European parallel to the flakes and cores described here is with the Tayacian (Breuil, 1932), a similarity on which the Abbé Breuil commented as soon as he saw the material from the Makapan Cave of Hearths. It is interesting to note that the Tayacian of France stands in precisely the same relationship to the Levallois as does the industry from the calcified sands at Riverview Estates or the Cave of Hearths to the Levallois of the Fauresmith. We must remember, however, that the Tayacian is regarded as a "pure flake" industry, whereas in South Africa the intimate association of flake and bifaced tools in the same cultures is generally recognised and is once again demonstrated here.

Van Riet Lowe has already drawn attention to the similarity between many of the bifaced tools of Stellenbosch V and the Micoquian. That comparison is now strengthened by the similarity between the flake tools of these cultures. The Acheulian (including the Micoquian) has constantly been regarded as a bifaced or "core" culture, and it was not until Harper Kelly (1937) described the flake tools of the Acheulian that sufficient attention was given to them. Kelley rightly emphasises that certain cultures in England and France "are pure flake cultures, with a complete absence of bifaces, but it is to be remembered that *all bifaced cultures have their flake tools as well*". Elsewhere he makes the significant statement that "at La Micoque the Abbé Breuil estimates that at least ten flake tools were found for every biface".

Kelley illustrates a large series of flake tools from all stages of the Acheulian, culled from large collections. He shows a much greater variety than the corresponding horizon in South Africa has so far produced, but includes many which do not appear to differ significantly from those of the corresponding horizon at Riverview Estates.

To summarise, a fairly complete sequence of development from Stellenbosch to Fauresmith can now be made out. We see handaxes and cleavers improving progressively up to Stellenbosch V, maintaining their refinement in the transition to Fauresmith, degenerating somewhat in Early Fauresmith times to experience a short-lived revival in the Upper Fauresmith before they finally disappear in Middle Stone Age times.

Forming an integral aspect of the same bifaced cultures we see, side by side with the progressive refinement of the handaxes and cleavers, the development of flaking techniques from the Victoria West or Proto-Levallois technique through Tayacian forms, such as those from the calcified sands and the Cave of Hearths, to the fully developed Levallois of the Fauresmith.

I am indebted to Professor van Riet Lowe for guidance and encouragement to describe material to which he has devoted a considerable amount of study since the joint geological and archaeological survey of the Vaal River Basin came to its untimely end ten years ago.

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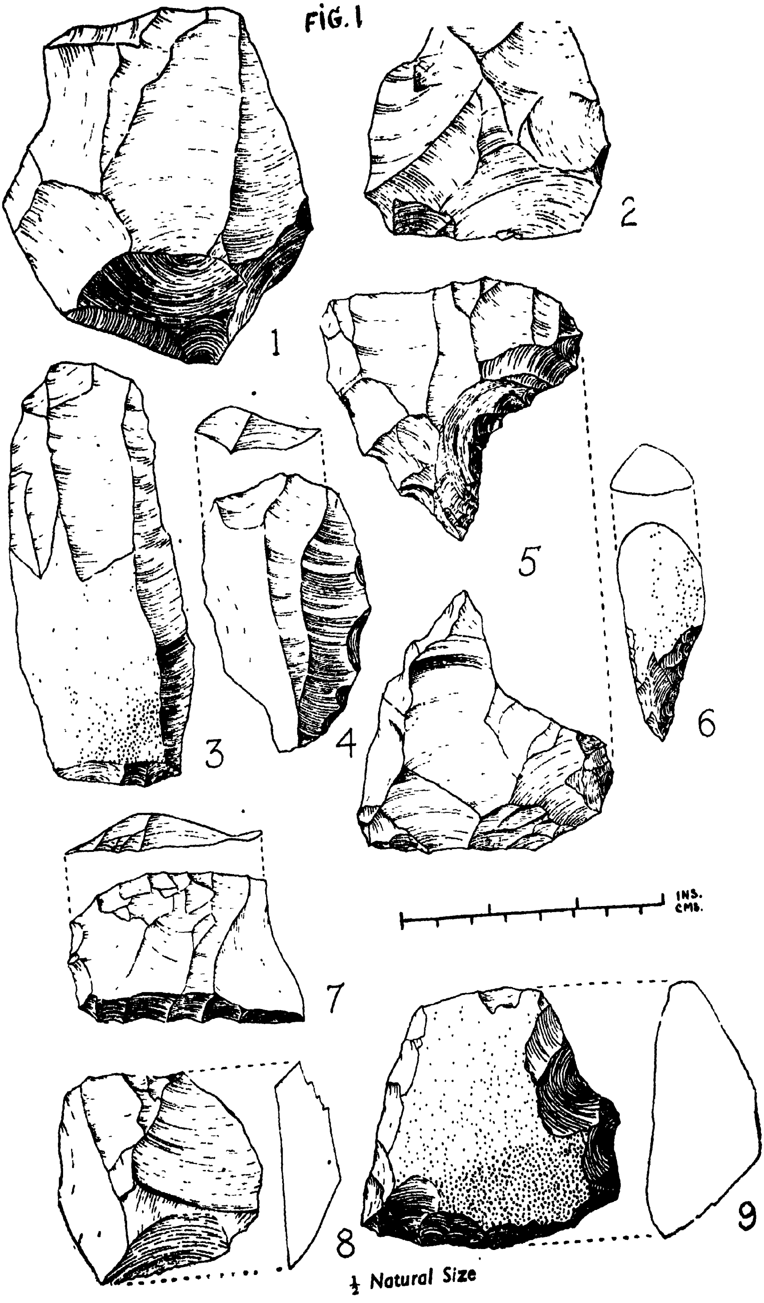

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FIG. II

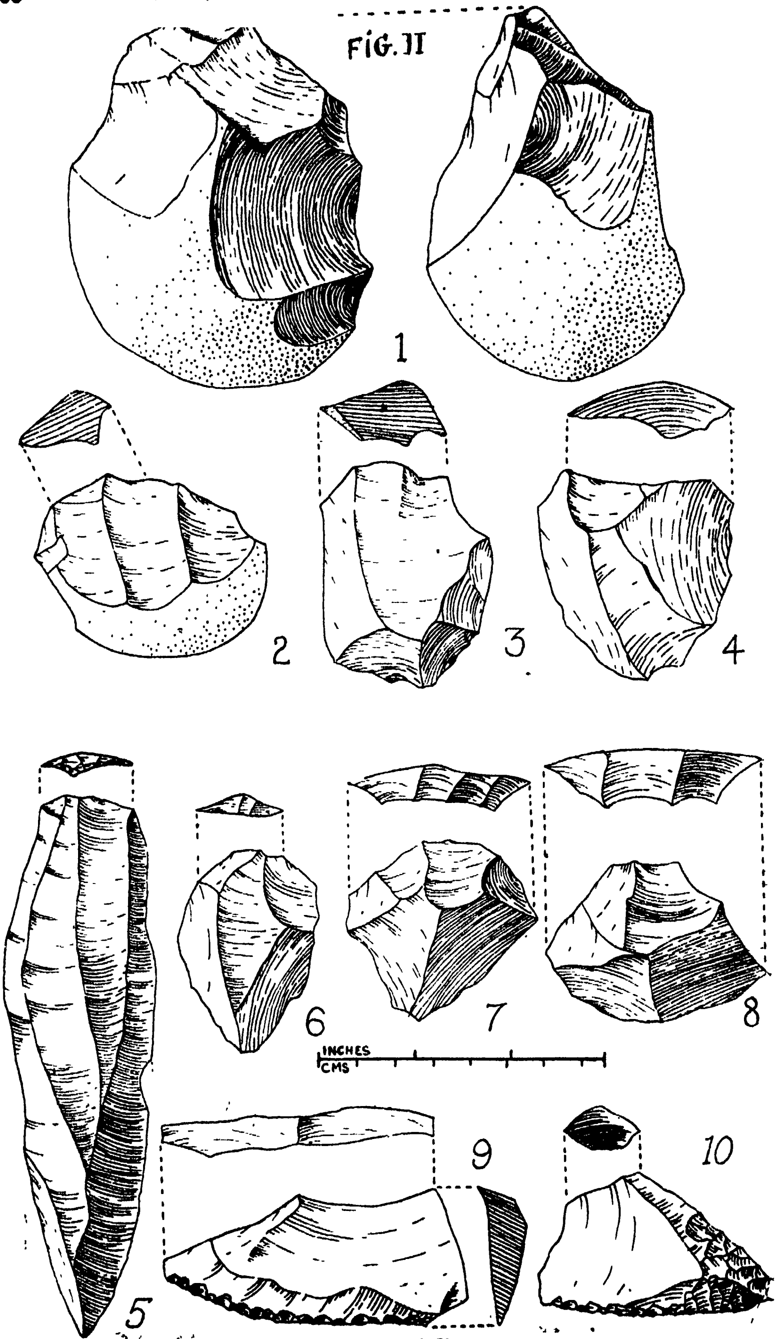

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FIG. III

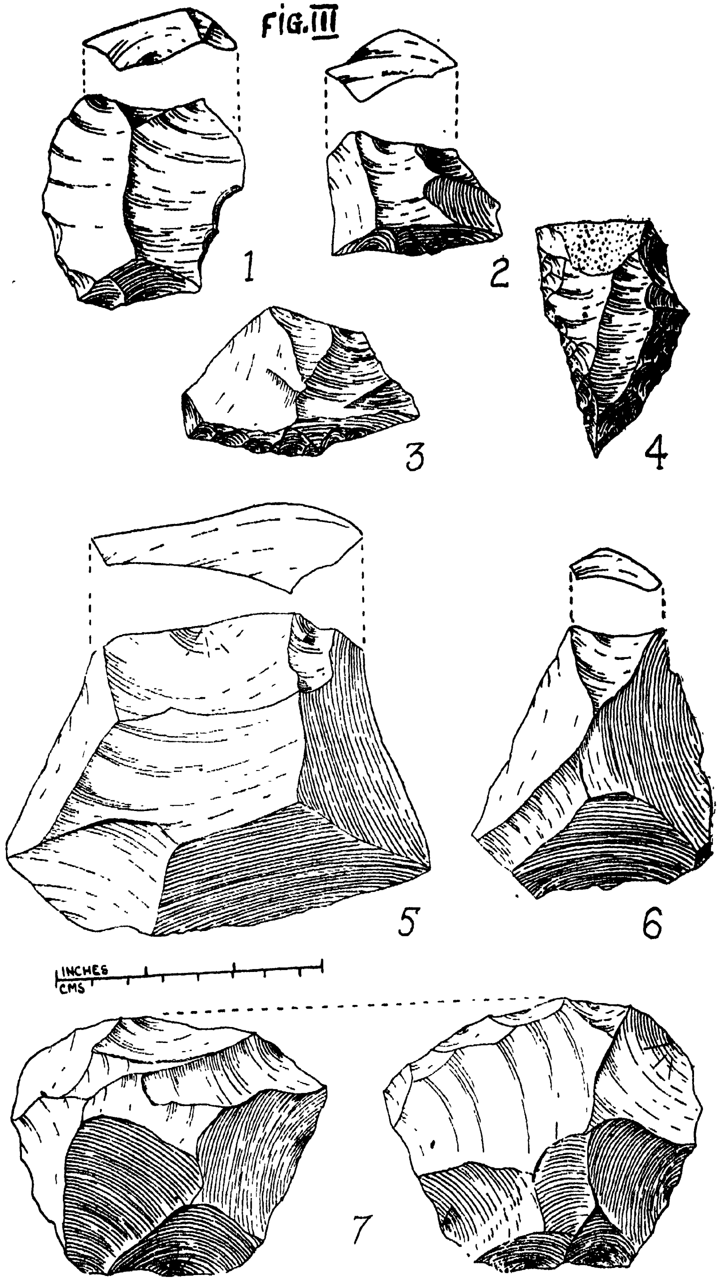

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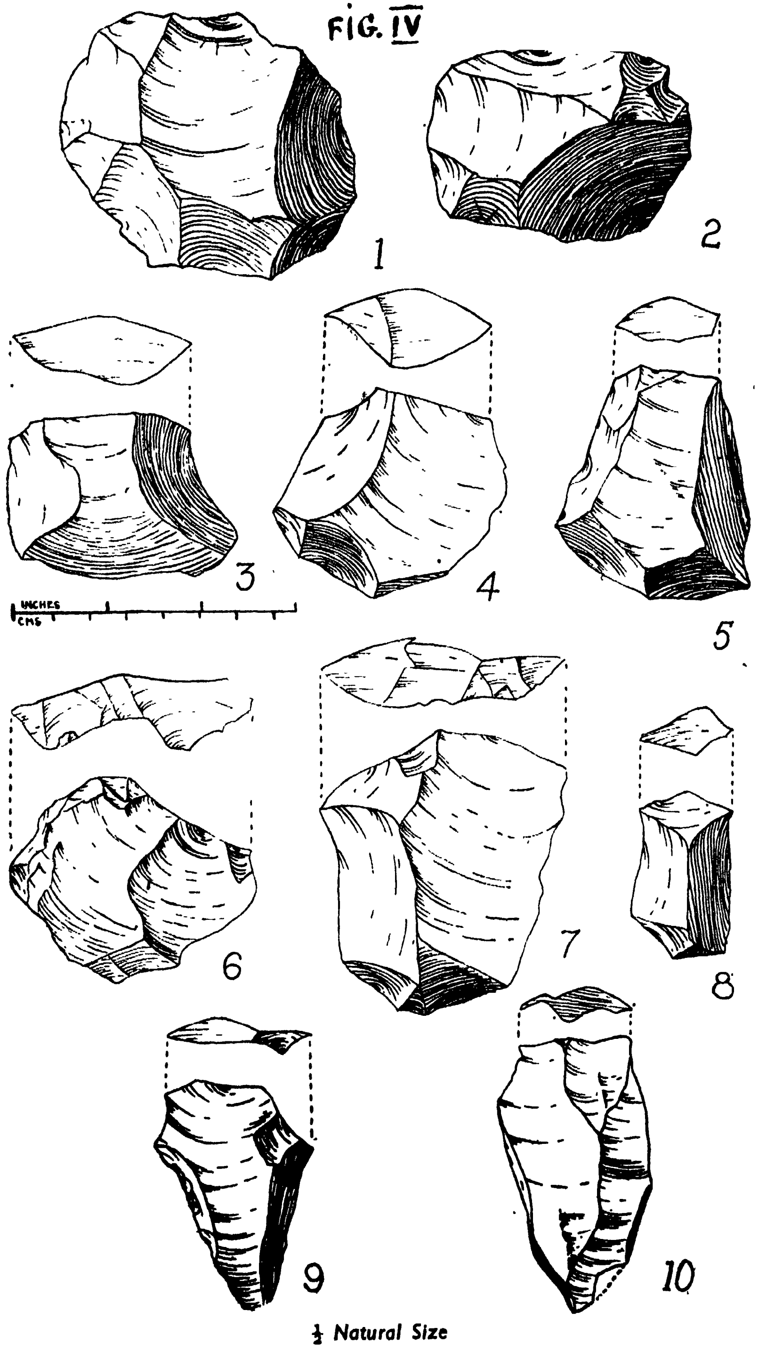
FIG. IV



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THE MARALI

BY

DR. LOUIS C. THOMPSON.

Read 2nd July, 1946.

The copper-smelters of various African tribes moulded their own type of ingots; that of the Ba-Luba of Katanga has the shape of the St. Andrews Cross; the Mu-Tsuku of the semitic Ba-Lemba, which was copied by the Ba-Venda, has the appearance of the trunk of a Baobab tree with the branches lopped off short; the marali of the Ba-Pedi resembles a knob-kerrie. The Ba-Pedi copper workers belonged to the clan of Sekororoa, a chief whose kraal was on the slopes of the Drakensberg, near the Makudzi River in the North-Eastern Transvaal.

Sekororoa appears to be a dynastic title, as there have been many generations of Sekororoas. More than a hundred years ago Louis Trichardt climbed the Drakensberg with his waggons, on his journey to Delagoa Bay. When descending the Berg, he passed Sekororoa's kraal on the Makudzi River, where some of his oxen were stolen; Trichardt recorded the loss of the oxen and the name of the chief in his diary.

The old copper workings of the Ba-Pedi are to be seen at Phala-Woroa (mis-spelt Palabora) and near the banks of the Makudzi River in the North-Eastern Transvaal. Their methods were the same as the Ba-Venda; they quarried the ore in open workings, the only exception being, that, in place of an iron gad, they used a wooden gad of assegai wood, which was hardened by firing; the head of the gad was protected by a circular quartzite stone, similar in shape to the so-called bushman digging stone.

The copper workings were in the charge of a headman, who marked out "mining claims" and collected from each claimholder a certain number of Ingots, which were handed to Sekororoa as tribute.

The late W. Valentine, who opened up some of the old workings at Phala-waroa, informed me that the workings were of two different periods; the later open workings of the Ba-Pedi and the earlier workings of a race of miners, who sank shafts; that when the lode opened out into a lens, the miners removed all the ore; that the resulting galleries, some of which were very large, were connected by passages (drives), which were so narrow that he found it difficult to squeeze his way along them. What race was responsible for the mines is not known; they were probably the work of the Ba-Lemba as the members of this tribe were the only people in Southern Africa who mined

gold, tin and copper, i.e. they sank a shaft on the ore-bearing lode, which they followed to water level.

The Ba-Pedi carried on the copper-industry to a late date, they were still working in 1869. Thomas Baines, in the "Gold Regions of S.E. Africa" describes the prospecting trip of Button, Sutherland, Parsons and McLachlan from Lydenburg to the North of the Limpopo River. In the description of their return journey on page 77, one reads the following:—

"Still further south among the Mosheshiman hills of porphyritic granite, they found natives working copper, but were not allowed to see any of the mines."

Thirty years ago the remains of their smelting furnaces were still to be seen.

Marali is the Sesuto name of the ingot which the Ba-Pedi moulded. It consists of a rod about 18 inches in length and 2 inches in circumference; at one end the rod expands into what I will describe as the head of the ingot; the head is difficult to describe, it has the appearance of a cone which has been somewhat flattened; on the head facing the stem are two horns 1⅛ inches in length; some specimens are decorated with four horns. The following is the description of three ingots, two of which are in my collection.

No. 1. Weight of Ingot . . . . 2 lb. 10 ozs.
Length of Stem . . . . 18½ inches.
Circumference of Stem . . . . 2 inches.

The head is conical, measuring 2 inches from apex to base; the base is 2 inches in diameter; the angle formed at the junction of the head and stem is 100 degrees. The head is undecorated.

No. 2. Weight of Ingot . . . . 2 lb. 4 ozs.
Length of Stem, which is hollow . . . . 18 inches.
Circumference of Stem . . . . 1¾ inches.

The head, which is flattened, measures 2 inches from apex to base; the base measures 2¾ ins. x 1¼ ins.; attached to the portion of the head which faces the stem are two horns, 1⅛ ins. in length. The angle formed at the junction of the head and stem is 100 degrees.

No. 3. Weight of Ingot . . . . 1 lb. 12 ozs.
Leigth of Stem, which is hollow . . . . 18 inches.

The head is decorated with five horns. As the head is highly decorated and the stem hollow, this ingot probably had a ceremonial use.

The ingots apear to have been moulded at one casting; the probable reason for the 100 degree angle between the head and stem was to allow the molten copper to gravitate along the mould to form the stem.

Forty years ago a Marali could be purchased from Sekororoa for the sum of one pound; to-day the ingots are very rare.

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A PRELIMINARY REPORT ON ARCHAEOLOGICAL SITES ON THE GROOT LETABA RIVER, NORTH-EASTERN TRANSVAAL

BY

Charles W. Bates.

Read 3rd July, 1946.

Introduction.

The farm "Eiland 134" is situated on the southern bank of the Groot Letaba River in the Rubbervale district of the North-Eastern Transvaal Lowveld. Eiland is 24 miles from Rubbervale and 44 miles from Tzaneen. The position is given by latitude 23° 39′ S. and longitude 30° 40′ E. On the farm is a hot mineral spring, which, although well-known locally, was neither described nor recorded until 1941. The surrounding country is flat bush-veld, the only prominent topographical feature being the Black Hills Range which forms the eastern boundary of the farm. Geologically, the vlei in which the hot spring is situated, is characterised by gneissic granite, with a prominent dolerite dyke of probable post-Karroo age traceable both to the north and south of the vlei. All rock samples submitted to the Geological Survey for examination were described as pre-Cambrian.

Description of Site.

The vlei is traversed by an intermittent watercourse, known amongst local natives as the Mamzabo, along which are to be found a large number of earth mounds containing potsherds, fragments of soapstone vessels, bone implements, stone tools and shells of river mussels and land snails. Stone Age factory sites occur in various parts of the farm.

The only published reference to these mounds is the following extract from "The Letaba Hot Spring", by Leslie E. Kent (Trans. Roy. Soc. S. Afr., Vol. XXIX, Part II): "The spring was known to and utilised by the native inhabitants, both as a bath and a source of salt, before the European settlement. This salt was obtained by lixiviating the mud through which the water issued and evaporating the resultant solution over open fires in clay pots. The heaps of extracted earth scattered over an area of about half a square mile near the edge of the vlei beside the Mamazapi (pronounced *Mamzabo* by local natives) watercourse are relics of this industry." Kent, however, makes no mention of the archaeological material with which the area abounds.

For the sake of easy reference I have divided the mound area into five sections, numbering them 1 to 5, and to each area

I have allocated a reference point. Eiland is a closed site in the sense that it has never before been investigated archaeologically or disturbed by vandals. Unfortunately, however, considerable erosion by flood water has taken place along the banks of the watercourse traversing the mound areas, and a great deal of archaeological material has been carried down to the Groot Letaba River and lost. In some places the mounds have collapsed into the watercourse making it impossible to trace the original horizons, with the result that potsherds and soapstone of different horizons are now found in hopeless confusion with stone age implements and modern Basuto pottery.

The Pottery.

Potsherds, in association with worked soapstone, are found in great abundance in and around the mounds. While some are probably recent, the bulk bear a strong resemblance to Sotho ware from various Northern Transvaal sites. I am not competent to attempt any analysis of the clay. I have tried rather, to classify the pottery in terms of standard of craftmanship and decorative motifs.

It is apparent that there are two types of pottery at the Eiland sites, which I have classified as E^1 and E^2:—

E^1: A very fine and smooth ware, sometimes less than ¼ in. thick, usually burnished brown, occasionally black, and comparatively rare. The colouring medium in the black pottery appears to be graphite and soot. Decorative motifs are simple, shallow and usually consist of diagonal cross hatching or extended herringbone hatching. Rims are seldom decorated. The sherds recovered mostly belong to globular pots without necks. The rims are rounded, bent outwards; there are few specimens without bevelling. The E^1 material taken to date is very fragmentary.

E^2: A coarse and often thick ware, usually matt but sometimes burnished in brown or black, a brick red matt finish being common. This ware exists in great abundance, and is usually made from a gritty grey paste. The decorations range from a poor and rough style of scratching on the wet clay, to very skillfully executed motifs done with an almost mathematical precision. E^2 pots almost invariably have necks, rim decoration being common. Many of the decorative motifs are identical with those on the ware from Mapungubwe.

Mound Area 1.—Mound Area 1 commences 50 yeards to the west of the hot spring and extends for 150 yards along both banks of the Mamzabo watercourse. The mounds are rich in both pottery and soapstone, and river mussel shells are more plentiful in these mounds than elsewhere. Most of the sherds

recovered from Mound Area 1 form part of globular pots and deep bowls of my E^2 classification, of which the following are examples:—

Fig. 1 (1): Globular pot with a flared neck, 10 ins. over the rim, in a gritty grey paste containing minute fragments of what appears to be quartz, exterior and neck inside being finished to a red matt surface. The rim is roughly rounded, the neck flared and slightly thickened and joins the body at a right angle. The decoration of a single row of comb impressions was made on the wet clay. Found at a depth of 2 ft.

Fig. 1 (2): Deep bowl, 14 ins. in diameter over the rim and 9 ins. in depth, in a fine grey paste. Exterior and neck inside are finished to a red matt surface. The rim is everted, the neck has a concave curve outwards, and joins the body at an angle with a slight break. Immediately above this is a double row of herringbone hatching, scratched on the wet clay with extraordinary neatness. The pot has been reconstructed from 40 fragments ranging in depth from 3 to 4 feet. Although lacking the burnish of the fine E^1 ware and very thick at the base, the bowl is constructed with perfect symmetry.

Mound Area 2.—Mound Area 2 extends from the precincts of the hot spring eastwards along the watercourse for 100 yards and extends inland away from the spruit for several hundred yards. A great quantity of sherds and soapstone has been ploughed up in lands irrigated from the spring. The pottery is very fragmentary but has yielded several fine sherds of my E^1 classification. One of the mounds, 15 ft. in height, has several large tambootie trees on the summit, an indication of the time that has elapsed since the industry was abandoned. I have taken sherds and soapstone from beneath the roots of these trees. The following examples of my E^1 ware are from this area:—

Fig. 1 (3): Fragment of a deep, slightly bellied bowl, about 10 ins. in diameter, in fine grey paste with a beautiful brown burnish inside and outside. The rim is rounded and everted and flows outwards into a slight belly. Decoration consists of a band of diagonal hatching. Surface find in bed of Mamzabo watercourse.

Fig. 1 (4): Bowl, in fine, dark grey paste, finished with a dark brown burnish outside and matt inside. The rim is rounded and slightly constricted. Decoration consists of 4 rows of alternate diagonal hatching, beautifully done. Found protruding from mound, 8 ft. from surface.

Mound Area 3.—This area has yielded several deep bowls, identical with Fig. 1 (3) except for differences in decoration. Although the vessels are well burnt and skilfully made, the decoration is often poorly executed, rough diagonal cross hatching being the most common. E^2 pottery in a variety of forms has

been found on this site, either in the bed of the spruit or protruding from the mounds. The following are examples:—

Fig. 1 (5).: Shouldered pot, about 8 ins. over the rim, in a dark clay, with a red burnish to the outside, while the inside of the neck is matt. The rim is rounded and the neck sweeps outwards to the shoulder in a graceful line. The neck is decorated with a series of double rows of herringbone hatching, curving downwards to the shoulder. The decoration was done with a V-shaped instrument, probably of bone. A surface find.

Fig. 1 (6): Globular pot, about 10 ins. in diameter with an opening 7 ins. across. In gritty grey paste and finished to a brick red matt inside and out. The rim is rounded and slightly everted. Decoration consists of a band of herring-bone hatching. This pot resembles pots made by Basuto women in this area to-day, and is probably of no great age.

Fig. 1 (7): Shouldered pot, in a smooth grey clay, burnt to a brick matt surface inside and out. The rim is pointed but rounded on the inside, and has a band of diagonal cross hatching externally. The neck is flared and has a band of diagonally hatched and slightly curved lines an inch below the rim decoration. This sherd was coated with a grey substance, difficult to remove, and bears every appearance of age.

Fig 1 (8): Bellied pot, in a fine red clay, the interior and exterior finished brick red with a matt surface. The rim is missing but appears to have been everted. The neck curves into the belly without a break. The neck is decorated with two rows of counter hatched diagonal lines in herring-bone fashion, the lower row being raised to form a projecting band around the pot. Below this is a series of hatched loops pointing upwards.

Fig. 1 (9): Bowl, in fine light grey paste containing fragments of quartz. Finished to a brick red burnish outside and a light brick matt inside. The rim is rounded and has immediately below it a band of herring-bone hatching executed with unsurpassed precision.

Mound Areas 4 and 5.—My examination of these sites has been at best cursory. Mound Area 4 is swampy and would require to be drained before a systematic excavation could be undertaken. Surface finds of pottery are very fragmentary and very little soapstone has been taken. The mounds are grouped around a marshy hollow, some 500 yards from the hot spring and to the west of the Mamzabo spruit. The marsh may be due to seepage from the spring, but appears to have its own subterranean source of water. River mussel shells are common; there is no salt in this area. The mounds are covered with mopani trees and grass. Two fossils, as yet unidentified, were taken here.

Mound Area 5 is situate some 600 yards from the hot spring on the western side of the watercourse. No soapstone has been

taken in this area, and pottery is less abundant. Several rocky outcrops occur, but the density of the undergrowth in the mopani thickets surrounding them is such that I have not yet investigated the possibility of rock shelter burials. Stone age flakes occur in the eroded areas. Both Mound Areàs 4 and 5 are worthy of closer attention than has so far proved practicable.

THE SOAPSTONE.

Soapstone is found in association with pottery in and around most of the mounds, but is most abundant in Mound Area 1. To date I have taken fragments of over 100 soapstone vessels and this is only a fraction of what still awaits the investigator. Most of the soapstone has been taken from the drift sand in the bed of the Mazabo watercourse, where it has been carried by flood waters. No talc deposits occur on this farm or on any of the farms in this area, the nearest being in the Harmony Block near Leydsdorp; others exist at Haenertsburg and in the Klein Letaba area. In the past a talc deposit has been worked on the farm Islington near Mica siding. The soapstone varies in colour from near white to reddish brown. All the specimens resemble each other more or less closely, but can be classified as follows:—

1. Talc-chlorite schists with a little actinolite.
2. Talc rocks containing chlorite and iron oxide.
3. Talc rocks containing actinolite.
4. Similar to No. 1 but with smaller percentage of chlorite.

Pure talc does not occur; all specimens contain actinolite, chlorite, or iron oxide in varying amounts.

Some specimens are more highly weathered than others. It is doubtful whether this can be used as a means of establishing the relative age of the carvings, as some have undoubtedly been more exposed to weathering agencies, and others may have been relatively weathered before they were carved. The fragments vary in weight from a few ounces to 25 lbs. Four types of carved vessels occur:—

1. Large oval platters, with rounded bases, up to 24 ins. in length. Fig. II (2).
2. Three-legged pots with vertical sides. Fig. II (1).
3. Shallow boat-shaped vessels with an unpierced horizontal lug at either end. Fig. II (3).
4. Shallow, flat bottomed bowls, roughly circular or oval, without lugs. Fig. II (4).

The lugged vessels are, for the most part, heavy, coarse and roughly carved. The three-legged pots are equally rough, the legs—*vide* Fig. II (5)—being very similar to the lugs of the Class 3, but smaller. The platters, however, show a much higher standard of craftsmanship, being finely carved and finished

to a smooth white surface. Rims are generally rounded on all types of vessels, but, unlike the Zimbabwe soapstone, there is no trace of decoration on any of the material taken. With the exception of the platters, the workmanship is coarse, even crude.

Exhaustive interrogation of local elderly natives has yielded no information whatever regarding the talc carvings. No traditions exist in connection with the Eiland sites. All the natives questioned have emphasised that a great period of time has elapsed since the industry was abandoned.

Miscellaneous Material.

Round hammer stones, grinding and pounding stones occur in all the mound areas. One large hammer stone was found in the Matipo spruit (Eiland) in association with Stone Age implements. A granite muller was taken in Mound Area 3.

Bone objects, mainly awls, are fairly common. The tapering object illustrated in Fig. I (11) was found among debris of a mound that had been undercut by flood water; it is corroded and heavily weathered. The awl illustrated in Fig. I (12) has a fresh and unweathered appearance.

Fig. II (8) represents a stone implement—probably a lance head, fashioned from an amphibole schist containing pyroxene and feldspar. The trimming technique is percussion.

Other Stone Age tools have been illustrated in Fig. II (7, 9 and 10), typical of many which exist in factory sites along the various spruits and at the foot of the Black Hills. Although in most cases the cutting edge is fairly straight, the tools are coarse and the trimming (where it exists) primitive. All these tools are fashioned from quartzite or metamorphic rocks containing amphibole, pyroxene or feldspar.

Allied Sites.

La Cotte and Marsalaal.—On both these farms, situated eight miles to the East and to the West of Eiland respectively, ancient smelting ovens have been found. A nozzle from a smelting oven recently discovered on La Cotte has been illustrated in Fig. I (10). The ovens appear to be similar to the Palaboroa smelting ovens, the ancient workings in the Palaboroa area being situated some 60 miles from the Eiland sites. Judging from the samples of slag shown me by the owner of La Cotte the substance mined by the early inhabitants appears to have been iron, but since none of this slag has yet been analysed it would be risky to over-emphasise this opinion. The possibility also exists that both iron and copper were mined here.

Chester.—The farm Chester is about 12 miles South-East of Eiland. A deep shell midden was discovered near the homestead of the owner some 10 years ago. The shells comprised

both river mussel and land snail and were very fragmentary. The owner showed me a shallow bowl, 14 inches over the rim, carved from a metamorphic rock, which was dug up near the homestead.

Matipo Spruit (*Eiland*).—At the Matipo site, situated 1¼ miles from the hot spring, I have taken Early Stone Age flakes and scrapers of quartzite and amphibole. A Stone Age factory site occurs in this area. A human femur, in a poor state of preservation and badly corroded, was taken here but has not yet been reported on.

Black Hills Site (*Eiland*).—An extensive Stone Age factory site occurs along the western side of the Black Hills.

Discussion.

Owing to the writer's lack of experience in practical archaeology, neither the potentialities nor the relative significance of the Eiland sites can be fully assessed in this paper. It is therefore proposed to confine discussion to the following points:—

1. Are the mounds surrounding the Letaba Hot Springs identifiable with the shell mound cultures found elsewhere in South Africa, or are they merely as Kent suggests heaps of extracted earth caused by the early inhabitants lixiviating the mud in the quest for salt?
2. Does the Eiland site possess affinities with any other early Bantu site?
3. Who were these early inhabitants?

1. I submit the following arguments in refutation of Kent's statement that the mounds are heaps of earth caused by early natives collecting salt:—

(*a*) The mounds contain land snails and river mussel shells, potsherds, fragments of soapstone vessels, bone and stone implements and other occupational debris. If the mounds represented the insoluble residue after the mud had been lixiviated they would not be impregnated with occupational debris.

(*b*) Natives extracting salt from the earth would not pile the extracted earth into neat heaps 15 feet in height.

(*c*) Cumbersome soapstone bowls, up to 30 lbs. in weight and easily broken would not be used for conveying salt over long distances. While the local inhabitants would certainly have come to the spring to collect salt, they are more likely to have conveyed that salt to their homes in clay pots. The presence of large numbers of heavy soapstone vessels can be taken as an indication that the mounds were an occupation area.

(*d*) Mound areas 4 and 5 occur in an area where there is no salt.

It has been noted by Laidler: "Shell mounds are always thickest along the banks and mouths of rivers, *or around springs.* They are not confined to coastal areas. Small middens of fresh water shells occur far inland." Much of the pottery taken from the Eiland mounds resembles material from the Coastal shell middens especially in rim sections, and similar rims have been found in association with an iron smelting industry (University site, Durban). Thus the occurrence at Eiland of mounds impregnated with shells and pottery having coastal affinities, and the occurrence on allied sites of a metal smelting industry, prompts me to suggest that the Eiland mounds are associated with the shell mound cultures described by Laidler and others. The presence of material not normally associated with shell mounds does not necessarily weaken this theory. Laidler has stated: "It has been shown that shell mound makers practised numerous cultures, and that this mode of subsistence is probably as old as man. The only ubiquitous implement is the pebble shell detacher. . . ."

2. It will be seen that my E^1 pottery resembles Schofield's (Mapungubwe) M^1 and Caton-Thompson's (Zimbabwe) Class B, whilst my E^2 seems closely related to the Mapungubwe M^2 and Caton-Thompson's Class A ware from Zimbabwe. Comparisons with the findings of other investigators would be a work in itself and beyond the scope of this paper.. Eiland is just over 200 miles from Mapungubwe by road and considerably less as the crow flies. Mapungubwe is therefore little further from Eiland than it is from Zimbabwe. The close resemblance between the pottery of the two sites, both in decoration and design, together with the geographical position of Eiland and Mapungubwe, suggests that the early inhabitants of the two sites may have practised the same or a similar culture, and may have belonged to the same or kindred stock.

The occurrence of worked talc rocks at both Eiland and Zimbabwe whereas none occur at Mapungubwe would indicate a link between the two former sites. However, it should be noted that while decoration was a feature of the Zimbabwe soapstone bowls, those taken at Eiland bear no trace of decoration. Furthermore, both the Zimbabwe and Mapungubwe peoples were builders in stone, yet no stone structures have been found at Eiland, nor, as far as I am aware, anywhere in the district, in spite of the fact that an abundance of stone suitable for building exists.

3. Our task is to decide to which of the ethnic groups the Eiland site can be assigned. I feel that the surest way of doing this would be on the basis of a classification of the pottery. Schofield has stated: "Our faith rests on the knowledge that pottery, which in every other field of archaeological research has proved a faithful guide, will not fail us in South Africa."

Although members of the Bush Race certainly occupied the Eiland site at some period, it is clear that the Eiland pottery has neither Bush nor Hottentot affinities. We can attribute it, therefore, to one of the five main Bantu language groups. We have already noted that the Eiland pottery strikingly resembles the ware from Mapungubwe , and that it bears a general resemblance to the pottery from the Natal coastal middens. The affinities with known Sotho sites, together with the geographical situation of this site, tend to indicate that the Eiland potters were of Sotho stock, with the possibility that, for a period at any rate, peoples of Sotho and Shona stock lived peacefully together, as appears to have been the case at Mapungubwe.

The main object in presenting this paper is to draw attention to the existence of these archaeological sites on the Groot Letaba River in the hope that they will be examined by investigators unfettered by the inexperience and ignorance of the present writer. As part owner of the farm Eiland I shall be delighted to extend a welcome, and grant every possible facility, to any archaeologist desirous of examining or excavating these sites.

ACKNOWLEDGMENTS.

I am greatly indebted to Mrs. J. H. H. Viljoen for her kindness in preparing the illustrations, and to the Director of the Geological Survey, Dr. S. H. Haughton, for furnishing me with a report on geological specimens from the Eiland sites.

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FIG. I

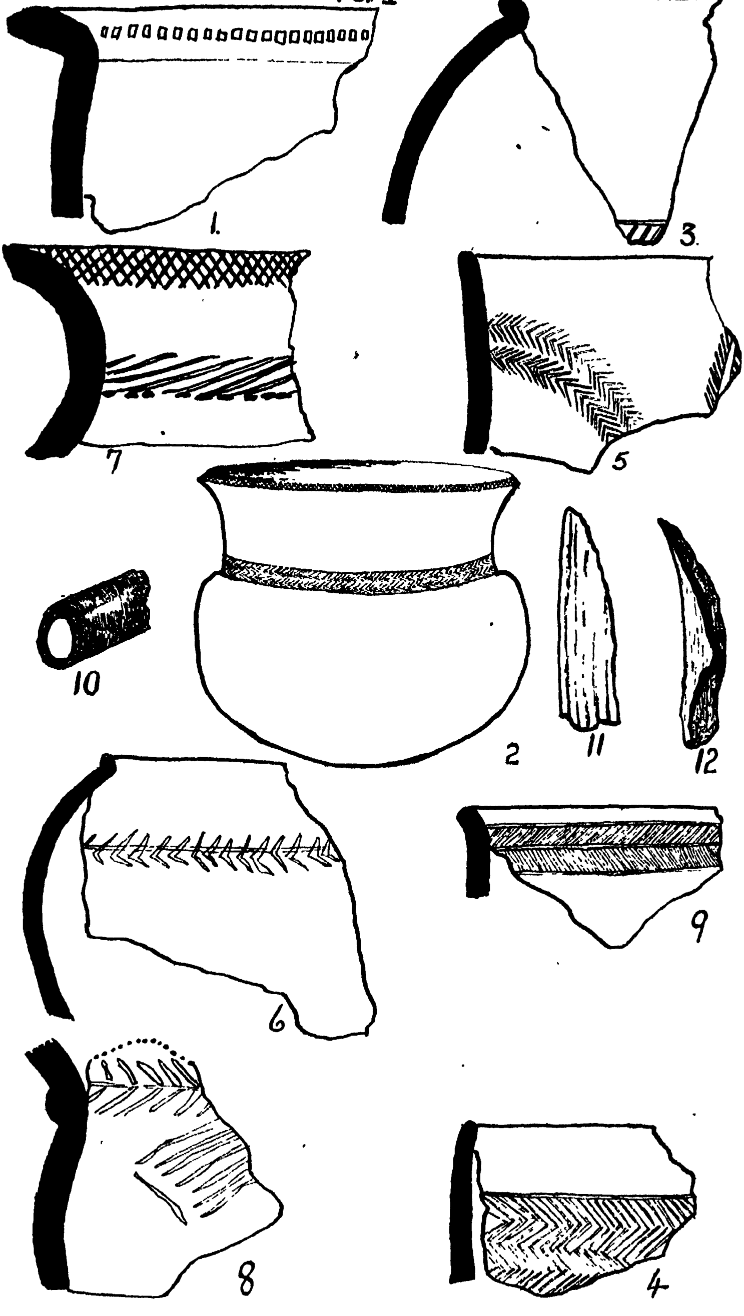
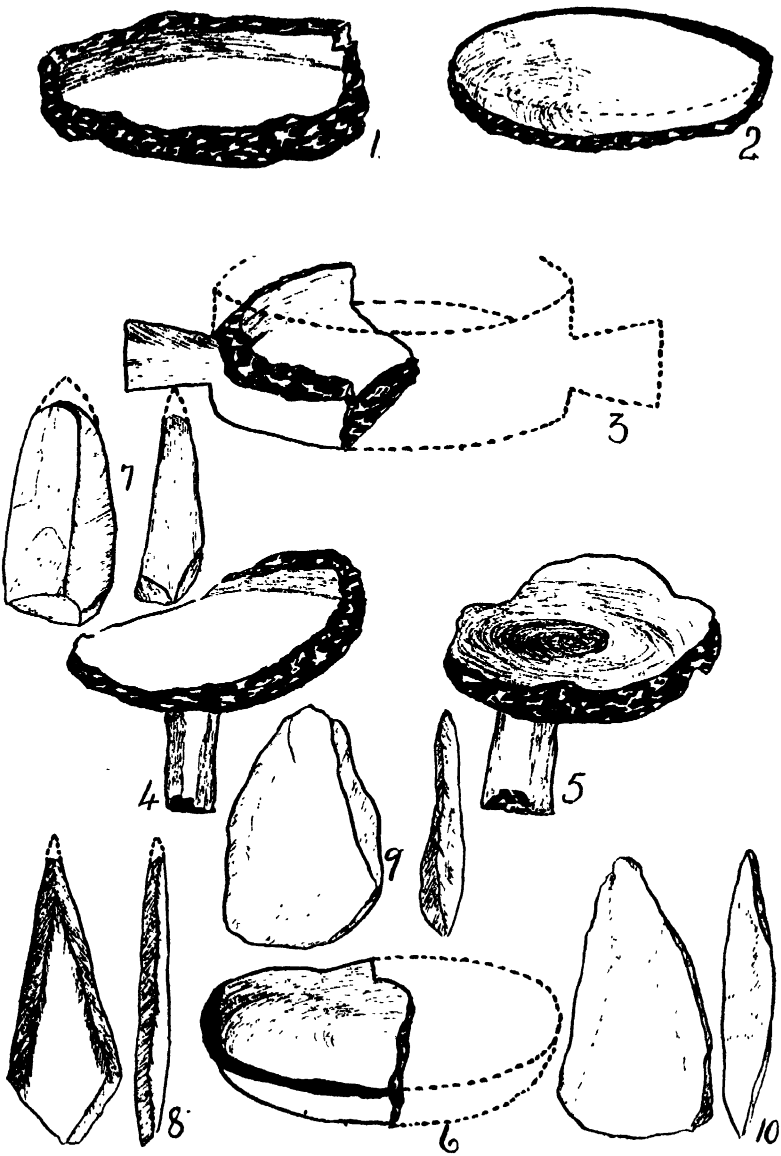


FIG. 2



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NEW FINDS IN THE "PIETERSBURG CULTURE OR VARIATION" AND THE PROBABLE USE OF A NEW TYPE

BY

John Harcus.

Read 5th July, 1946.

(A) Navis Type.

In my "Primrose Ridge" paper, read before this Association in 1944, a type of stone implement not previously recorded was illustrated and described (Plate "Y"—1.2.3—1944). It was a boat-shaped Point for which I suggested the name "Navis". At the conference, Professor van Riet Lowe remarked that he would not be surprised if this type turned up in the "Pietersburg variation". A week later I found a perfect specimen of the type in fine red felsite, in the new "Du Breuyn Donga", near Uitloop, north of Potgietersrust. Probably because this material is more pliable than the white quartz of Primrose, this symmetrical 3-inch long specimen is a perfect piece of craftmanship and is in mint condition. About a quarter of a mile from the donga, and in the railway embankment which skirts it, I found a small more weathered specimen in fine felsite, lacking a ¼-inch of the tip. This one would be about 2⅜ inches long if the tip were restored. The reverse, in both cases, is a clean plane, slightly concave in its length, with no bulb of percussion. The illustration to my "Primrose Ridge" paper (1944), Plate "Y"—1, pictures the new felsite specimens perfectly.

(B) Wavy Points.

In a brief paper given in July, 1945, three wavy points from various Pietersburg sites were described (1945). All three had at least one inch off the tip or point; all were in a very granular felsite, worked conversely on both obverse and reverse faces, and all were deeply scalloped along both edges. In July, 1945, in the new "Du Breuyn Donga" near Potgietersrust, I found a fourth (Plate "X" No. 1). It is the most perfect one of the lot, lacking only ¼-inch of the tip, in the same coarse red felsite, and deeply scalloped along both edges. The choice of coarse granular felsite is uncommon, and the four specimens, all of the same type, all in this seldom-used material, are noteworthy. Of my hundreds of specimens from the Pietersburg areas only two others are in this material. Like the specimens previously found, this fourth one shows little weathering or patination. It is 3¾ inches long, 1⅜ inches base width and ½ inch in extreme thickness. Two butts are erratic, the third specimen (which is short of 1¼ inchs of its point) has a prepared platform,

and shows step-flaking at the butt on its more convex face, as if to facilitate hafting. These remarkable points were hewn from edge to centre, scallop by scallop. In each both faces are convex but, in each case, one face is slightly less convex than the other. These bifaced Points are triangular or sub-triangular in plan (i.e., their butts or bases are not rounded) and are generally thicker and heavier in cross section than the well-known bifaced Still-bay (or Silutrian Type) Points. The use of this granular material, the absence of a bulb percussion, the convexity of both faces, the brutal jagged edges, especially in the last one found (Plate "X" No. 1), the careful removal of fluting flakes, which produced the scalloped edges, and the elimination of the median ridge, indicate characteristics which are not common in the "Pietersburg Culture". They suggest a technique generally connected with the products from Central rather than from South Africa. A three-inch long fragment of a similar specimen in a comparable granular material is in the Belgian Congo case of the Archaeological Survey at Johannesburg. The presence of these unfamiliar specimens in the Pietersburg dongas suggests either the visit of an individual or tribe from Central Africa, or indicates a culture predating the Pietersburg Variation of the Middle Stone Age, as originally described by Goodwin (1929). When Mr. B. D. Malan's description of the "Pietersburg Culture" (as a *Culture*) is finally published, it may be found that these comparatively thick sub-triangular bifaced Points belong to the earliest stage of the development of the Culture, and thus provide a typological link with the final phase of the preceding "Fauresmith Culture" (van Riet Lowe, 1944), with elements that recall the "Tumbian Culture" as defined by Leakey (1945).

(C) SKIM-STONES.

In a previous paper (1945), I suggested the name "skim-stone" for certain bifaced and occasional unifaced thin artefacts from the "Pietersburg Culture". No. 3 Plate "X", illustrates a bifaced type. These possible skim-stones include bifaced artefacts commonly known as discoidal (Levallois) cores, as well as unifaced implements, generally referred to as circular scrapers. They occur in comparative abundance on all known Middle Stone Age sites in the Transvaal and elsewhere. I have further examined and handled my representative collection of these discs and their scalloped sharp edges, and again stress that, although primarily discarded cores, they could have been used as skim-stones against waterfowl on a pool, and would also be very useful weapons in tribal warfare. Launched flatly from the hand, or hurled from a sling, I see no reason why they should not have been effective in this manner. That such laboriously worked specimens as the hundreds of bifaced Levallois cores were mere discards and had no utilitarian value

beyond their use as cores, seems unreasonable when one examines their perfect shaping and keen scalloped edges. I refer particularly to disc-like specimens, from 2 ins. diameter, ½ in. thick, to say 4 ins. diameter by ¾ in. May I suggest that collectors examine and "handle" their discoidal artefacts, both cores and scrapers, and test this possibility for themselves.

(D) A Re-made "Point"—Plate "X" No. 2.

A re-made Point, in coarse gray felsite, showing remarkable skill, is from the new "Du Breuyn Donga". It is 2¾ ins. x 1⅝ ins. extreme, and only ¼in. thick. The top left-hand section of the original face of this Point, about one-eighth of the area of the face, is possibly the only portion of the original surface of the "Point" left. This one-eighth of the face has a rich bronze patina, with weathered-out pitting and a "bloom" that indicates great age. The butt is recent, the bulb and the whole reverse flake-surface seem too fresh to belong to the original "point". From the fresh butt, three longitudinal primary flakes have been struck, without damaging the original tip. The fine serrations of the original edge have been deftly reproduced along the comparatively thick left edge, and on the thin right-hand edge. This re-make of a thin delicate specimen, without damage to the original tip is, I consider, worthy of record. (Plate "X" No. 2.)

(E) "Serrators".

Finds in the "Uitloop Donga" and the adjacent "Du Breuyn Donga" in July, 1945, set the seal on similar specimens from the Kowie, the dongas near Naboomspruit and the Primrose Ridge excavations of 1943-1944. They total up to 28 of a type, the coastal specimens averaging 2½ ins. long, while the largest inland specimens (from Uitloop) are between 4½ ins. and 5 ins. in length. These peculiar long finger-like tools set me experimenting. Eleven are shown in Plate "Y". Of these, "P.A." is from Port Alfred, and "P.R." from Primrose Ridge. The others are from sites in the Pietersburg district. The one sketched on Plate "X" is "U" in Plate "Y". It is 5 ins. long and of hard granular sandstone. The type is triangular in cross-section, more isosceles than equilateral, and has a marked twist in it. Some show working damage at both ends; nearly all show damage at one end—and that the thin end. The sketch, Plate "X" No. 4 B, shows this special "tool" in hand. In action, the forefinger would be almost at right angles underneath, the thumb much further forward and fully on the flat face. (Plate "X" No. 4 C). On experiment, it is evident that notching along the edges of Points could be delicately produced by an upward pressure method with a tool of this type. Such pressure flaking would cause little damage to the serrator itself, while achieving very fine regular controlled notching. The edge being serrated

would be in full view while being shaped. These stout long artefacts, found in areas hundreds of miles apart, are not, in my opinion, waste products, but are deliberately shaped or chosen *fabricators* or "serrators", used for direct pressure flaking. In Plate "Y", the specimen at the left lower corner is a typical backed blade of "quarter orange" type, but it is included in the Plate because of its truncated (upper) end; this truncation being a feature of the serrators. I experimented with a "quarter orange" of white quartzite, and serrated the edges of seven flakes in various materials, with only slight bruising of the truncated end. "Fabricator" is a term applicable to several types of trimming stones; I suggest "Serrators" for these tools for fine pressure-dressing purposes.

"Dr. L. S. B. Leakey (1931) has described certain blades, triangular in cross-section, with one or more edges bruised and damaged by their use as fabricators for effecting the secondary trimming on backed blades by pressure fracture. These, he says, are common in the Kenya Aurignacian, and called "Aurignacian fabricators". While Dr. Leakey's tools are similar in general form to those which I have described, my specimens do not show the long bruised edges which characterise his specimens. In mine it is the blunted points, not the edges formed by the inter-section of the three faces of the blades, which show damage through use as "Serrators" in the manner I have suggested."

(F) Beaked Blades.

Plate "X", No. 5, shows a type of implement in black felsite from the "Harcus Donga", near Naboomspruit. Plate "X", No. 6, shows another, in fine red felsite, from Uitloop. Both are boldly worked along the convex edge, while the opposite concave edge is one clean sweep. A third, much heavier specimen, just under one inch thick, has the serrations on the opposite edge to the other two, and is perhaps for the left hand. This is illustrated in *Plate "X", No. 7* in heavily patinated coarse-grained quartzite, and is from the "Salusbury Donga". I suggest the name "Beaked Blades" for such types.

In completing this series of papers, it will be evident that I am still following "Sayce", giving publicity to "enigmas" and "Independent inventions". With him, my claim is that it is an obstruction not to do so, as "it is only information of this kind and its publicity that can make our studies alive and practical, and so supplement the valuable teaching that can be obtained from our ethnographical collections" (1933).

In conclusion, I wish to express my indebtedness to Professor van Riet Lowe for his ready advice in many helpful discussions. His great knowledge of the subject has been ungrudgingly given to guide my amateur enthusiasm past many pitfalls, and has greatly encouraged me for the last ten years.

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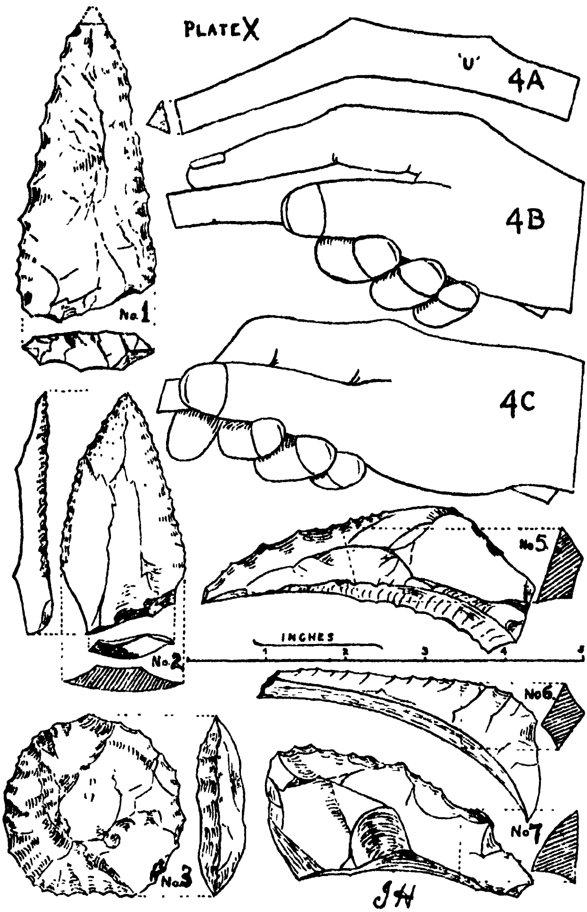
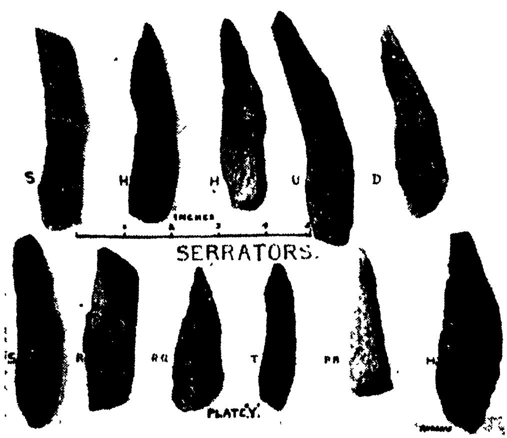


PLATE X
'U'
4A
4B
4C
No. 1
No. 2
No. 3
No. 5
No. 6
No. 7
INCHES
JH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